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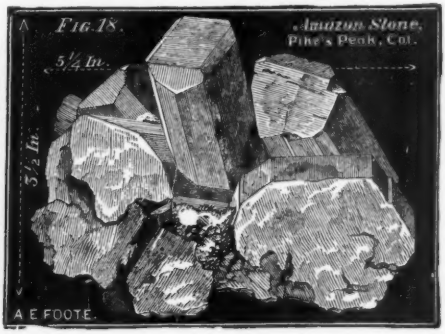


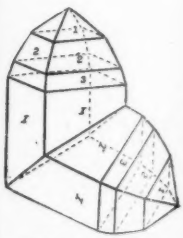

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THE

# AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. VII.—*On the Chemical Composition of Staurolite, and the regular arrangement of its Carbonaceous Inclusions;* by S. L. PENFIELD and J. H. PRATT.

*Historical.*—In the early analyses of staurolite, especially those of Jacobson* and Rammelsberg,† a great variation was found in the chemical composition, especially in the amounts of silica, which varied all the way from 27 to 50 per cent. The iron oxide, moreover, was regarded by some investigators as ferric, by others as ferrous, while still others considered that it existed in both states of oxidation.

In 1865 Lechartier‡ observed that pulverized staurolite from Brittany and Bolivia, when examined with the microscope, showed both brown and colorless grains. On treatment with hydrofluoric acid, it was found that the colorless ones dissolved, while the staurolite was very slightly attacked. Furthermore, material purified by this treatment was found to be nearly uniform in specific gravity and gave amounts of $SiO_2$ varying from 28–29 per cent, agreeing with the purest staurolite from St. Gothard. He also proved that water was an essential constituent of the mineral.

In 1872, von Lasaulx§ showed, from a microscopic examination of staurolite from various localities, that all crystals are more or less impure from mechanical admixtures, especially of

* Pogg. Ann., lxii, p. 419, 1844 and lxviii, p. 414, 1846.
† Pogg. Ann., cxiii, p. 599, 1861.
‡ Bull Soc. Chemique, iii, p. 378.
§ Min. Mittheilung, 1872, p. 173.

quartz, while garnet, cyanite, magnetite and mica were also observed. These inclusions of quartz, amounting sometimes to 30–40 per cent of the total weight of the crystal, account for the great variation of the silica percentages in the older analyses.

In 1873 Rammelsberg* reëxamined the exceptionally pure staurolite from St. Gothard and also the impure material from Pitkäranta and Brittany, in which he had previously found over 50 per cent of silica. After purifying these latter by treatment with hydrofluoric acid, only from 29 to 30 per cent of silica was found and the analyses agreed with that of the St. Gothard mineral. From these analyses he deduced the formula $H_2Fe_2Al_{12}Si_6O_{34}$, the iron being regarded as ferrous and replaced in part by magnesia.

In 1885 Friedl† investigated carefully selected material from St. Gothard and Tramnitzberg in Mähren, which by examination with the microscope had been found to be free from foreign inclusions. From the results of his analyses he deduced the formula $H_4Fe_6Al_{24}Si_{11}O_{66}$. In the same year Coloranio‡ analyzed the St. Gothard staurolite, which had been carefully selected and digested with hydrofluoric acid, the formula deduced by him being $H_2Fe_2Al_{12}Si_5O_{31}$.

It is interesting to note the variations in the proposed formulæ, each investigator in turn finding a smaller amount of silica as shown below, where the formulæ of Rammelsberg and Coloranio have been doubled for more ready comparison.

| | |
|---|---|
| Rammelsberg | $H_4Fe_6Al_{24}Si_{12}O_{68}$ |
| Friedl | $H_4Fe_6Al_{24}Si_{11}O_{66}$ |
| Coloranio | $H_4Fe_4Al_{24}Si_{10}O_{62}$ |

From a consideration of the analyses of Friedl and Coloranio Groth§ concludes that staurolite has a still simple formula and suggests a basic orthosilicate $(AlO)_4(AlOH)Fe(SiO_4)_2$.

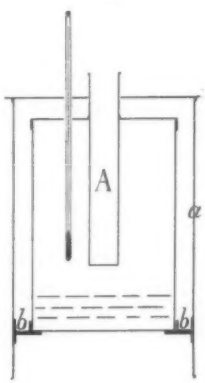
*Selection and preparation of material for analysis.*—In the present investigation, material of exceptional purity was selected from the four following localities: St. Gothard, Switzerland; Windham, Maine; Lisbon, New Hampshire and near Burnsville, North Carolina. The material from the first of these is too well known to need special description. Some crystals from the Brush collection were available. At Windham, Maine, it occurs in crystals measuring up to 25$^{mm}$ in diameter, imbedded in mica schist, as represented by an excellent suite of specimens in the Brush collection. This has

* Zeitschr. Deutsch. Geol. Gesell., xxv, p. 53.
† Zeitschr. Kryst., x, p. 366.
‡ Bull. Soc Chemique, xliv, p. 427.
§ Tabellarische Uebersicht der Mineralien, 1889, p. 104.

never been previously analyzed. The material from Sugar Hill in Lisbon, N. H., was collected in the summer of 1893 by Prof. G. J. Brush. As observed by him extensive ledges of gray, staurolitic mica schist occur, extending several miles north from Pearl Lake, better known as Mink Pond, and including the ledges on Garnet Hill and Cowen Hill. In the ledges on Cowen Hill unusually large and fresh crystals are found, measuring up to 115$^{mm}$ long by 40$^{mm}$ broad. Thin sections of these crystals revealed the fact that they are remarkably free from inclusions of quartz and garnet, which are so common in staurolite, but they contain carbonaceous material arranged in certain definite planes, as described later. The staurolite from near Burnsville was collected by the writers in the summer of 1892, while engaged in work for the North Carolina Geological Survey. It was found at and near a prospect pit on the property of Mr. D. M. Hampton, which had been dug in exploiting for iron ore. The associated minerals are magnetite, menaccanite and corundum. The staurolite occurs in crystalline aggregates, often intimately associated with the iron ores.

In the preparation of material for analysis the carefully selected crystals were pulverized and sifted to a uniform grain. In the case of the North Carolina mineral the magnetite and menaccanite were removed by means of an electro-magnet. In order to separate a powder of uniform specific gravity the use of fused silver nitrate, which can be diluted with potassium nitrate was resorted to, as recommended by J. W. Retgers.* It was found convenient to use a double walled, cylindrical, copper air bath, shown in section in the accompanying figure. The outer cylinder *a* stands on legs which are not represented. The inner bath is supported by brackets, *b*, and is provided with several perforated discs near the bottom, which serve to disseminate the heat of the lamp. The well *A* holds a test tube containing the silver nitrate, which can readily be kept in a state of fusion and at a constant temperature for any desired length of time; this latter condition being very essential in order to avoid circulating currents. The fusing point of silver nitrate is 198° C. but the temperature which was found most convenient for work was about 250° C. The specific gravity of fused $AgNO_3$

1.




* Jahrb. f. Min., 1889, ii, p. 190.

is about 4·1 which can be lowered by addition of $KNO_3$. The fused salt is a clear mobile liquid, through which the particles of mineral move freely, and separations can be made in this as accurately as in any of the heavy solutions. On cooling, the fusion solidifies to a cake with the heavier and lighter portions at the bottom and top respectively. The test tube readily breaks away from the fused mass, the cake can be cut in two and the minerals separated by dissolving the nitrates in water. The latter can be reclaimed by evaporating the solutions to dryness on a water bath and finally fusing. By eliminating the heavier and lighter portions and repeating the separation remarkably pure products were obtained, of nearly uniform specific gravity. The manipulations are very simple and the results extremely satisfactory. A preliminary experiment that was made showed that staurolite does not suffer any decomposition or loss in weight when exposed to a temperature of 250° C. The separated material, when examined with the microscope, was found to be homogeneous and very free from visible inclusions.

*Method of analysis.*—The silica and bases were determined by well known methods. The evaporations were carried on in platinum, the purity of the silica tested by evaporation with hydrofluoric acid and account taken of the small quantity of silica carried along and weighed with the sesquioxides. Especial pains was taken in the determination of ferrous and ferric iron. The very finely pulverized mineral was treated in a small platinum bottle with a mixture of strong hydrofluoric and sulphuric acids and boiled vigorously for about twenty minutes, the neck of the bottle being covered by a cone of platinum foil. The contents of the bottle were then diluted with cold, boiled water, washed into a casserole and titrated with potassium permanganate. Preliminary experiments were made by treating known weights of ferrous sulphate in the same manner and it was found that no appreciable oxidation from the air took place. As the staurolite is very slowly attacked by hydrofluoric acid only a portion in each experiment went into solution. After titration, the insoluble portion was filtered off and the filtrate evaporated in a platinum dish till all the hydrofluoric acid was expelled. After diluting, the iron was reduced by hydrogen sulphide, the excess of the latter removed by boiling and the total iron determined by means of potassium permanganate. The determinations give the ratio of ferrous to ferric iron in that portion which had been dissolved by the hydrofluoric acid, and the total iron in the mineral having been previously found in that portion used for silica and bases, the percentages of ferrous and ferric iron are readily calculated. Direct determinations of water were

made in all cases, as loss by ignition would naturally give too low results, owing to the oxidation of the ferrous iron.

*Analytical results.*—The results of the analyses are given below, together with the specific gravity determinations which were made very carefully by means of the pyconometer.

*St. Gothard, Switzerland.*

Specific gravity = 3·748.

| | I. | II. | Average. |
|---|---|---|---|
| $SiO_2$ | 27·80 | 27·65 | 27·73 |
| $Al_2O_3$ | 53·23 | 53·35 | 53·29 |
| $Fe_2O_3$ | 2·83 | 2·83 | 2·83 |
| FeO | 11·21 | 11·20 | 11·21 |
| MnO | ·63 | ·44 | ·53 |
| MgO | 1·77 | 1·85 | 1·81 |
| $H_2O$ | 2·19 | ---- | 2·19 |
| | | | 99·59 |

*Windham, Maine.*

Specific gravity = 3·728.

| | I. | II. | III. | Average. |
|---|---|---|---|---|
| $SiO_2$ | 27·81 | 27·88 | ---- | 27·84 |
| $Al_2O_3$ | 54·44 | 54·51 | 54·36 | 54·46 |
| $Fe_2O_3$ | 2·81 | 2·90 | 2·80 | 2·83 |
| FeO | 10·52 | 10·85 | 10·44 | 10·60 |
| MnO | ·59 | ·62 | ·56 | ·59 |
| MgO | 1·83 | 1·87 | ---- | 1·85 |
| $H_2O$ | 2·24 | ---- | ---- | 2·24 |
| | | | | 100·41 |

*Lisbon, New Hampshire.*

Specific gravity = 3·775.

| | |
|---|---|
| $SiO_2$ | 27·81 |
| $Al_2O_3$ | 54·09 |
| $Fe_2O_3$ | 2·76 |
| FeO | 12·48 |
| MgO | 1·92 |
| $H_2O$ | 1·70 |
| | 100·76 |

*Burnsville, North Carolina.*

Specific gravity = 3·773.

| | I. | II. | III. | IV. | Average. |
|---|---|---|---|---|---|
| $SiO_2$ | 27·80 | 27·65 | 27·59 | 27·77 | 27·70 |
| $Al_2O_3$ | 53·09 | 53·30 | ---- | 53·27 | 53·22 |
| $Fe_2O_3$ | 4·81 | 4·81 | 4·83 | 4·85 | 4·82 |
| FeO | 9·70 | 9·68 | 9·74 | 9·79 | 9·72 |
| MnO | ·27 | ·38 | ·33 | ·36 | ·34 |
| MgO | 2·64 | 2 65 | 2·70 | ---- | 2·66 |
| $H_2O$ | 1·99 | 1·96 | ---- | ---- | 1·97 |
| | | | | | 100·43 |

For a better comparison of the above results the average analyses are given below, after recalculating $Fe_2O_3$ as $Al_2O_3$, MnO and MgO as FeO and bringing the whole to one hundred per cent.

| | St. Gothard, Switz. | Windham, Me. | Lisbon, N. H. | Burnsville, N. C. |
|---|---|---|---|---|
| $SiO_2$ | 27·70 | 27·60 | 27·44 | 27·47 |
| $Al_2O_3$ | 55·04 | 55·75 | 55·16 | 55·83 |
| FeO | 15·07 | 14·43 | 15·72 | 14·74 |
| $H_2O$ | 2·19 | 2·22 | 1·68 | 1·96 |
| | 100·00 | 100·00 | 100·00 | 100·00 |

The ratios in these analyses are as follows:

| | $SiO_2$ : | $Al_2O_3$: | FeO : | $H_2O$ | |
|---|---|---|---|---|---|
| St. Gothard | ·460 : | ·540 : | ·209 : | ·121 | = 2·12 : 2·50 : ·967 : ·560 |
| Windham | ·460 : | ·546 : | ·200 : | ·122 | = 2·11 : 2·50 : ·915 : ·557 |
| Lisbon | ·457 : | ·540 : | ·218 : | ·093 | = 2·11 : 2·50 : 1·01 : ·430 |
| Burnsville | ·458 : | ·547 : | ·205 : | ·109 | = 2·07 : 2·50 : ·934 : ·497 |

The above ratios approximate closely to 2 : 2·5 : 1 : 0·5 which would give the formula $HAl_5FeSi_2O_{12}$, in which the aluminium is partly replaced by ferric iron and the ferrous iron by magnesium and manganese. This is, moreover, the formula suggested by Groth, and, as previously stated, may be written as a basic ortho silicate, $(AlO)_3(AlOH)Fe(SiO_4)_2$ or equally well, $(AlO)_4Al(FeOH)(SiO_4)_2$. The percentage composition required by the formula is the following:

| | |
|---|---|
| $SiO_2$ | 26·32 |
| $Al_2O_3$ | 55·92 |
| FeO | 15·79 |
| $H_2O$ | 1·97 |
| | 100·00 |

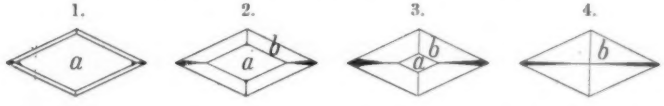
From a comparison of the ratios, or of the analyses, as reduced, with the theory, it will be observed that the silica is uniformly a trifle high, amounting to something over one per cent. This cannot be referred to an analytical error, as the distilled water and reagents were pure, and platinum vessels were used for the evaporations. It was not derived from the agate mortar in which the mineral was ground, for in the analysis of the mineral from Lisbon a steel mortar was used, the powder being afterwards purified by treatment with hydrochloric acid. From the careful selection of nearly pure mineral to start with, and the special precautions that were taken to eliminate all heavier and lighter portions by the specific gravity separation, it was not expected that the staurolite grains would still contain inclusions of quartz, nor were they

visible in the fragments, when examined with the microscope; from the results of the analyses, however, it is evident that they were not wholly eliminated. To test this point more carefully, the following experiments were made on some of the finely powdered minerals left over from the regular analyses. After digesting with cold, strong hydrofluoric acid for twelve hours and washing, silica determinations were made, which are given below, along with the determinations from the previous analyses.

| | St. Gothard. | Windham, Me. | Lisbon, N. H. |
|---|---|---|---|
| $SiO_2$ after treatment with HF., | 27·52 | 27·36 | 27·15 |
| " from regular analyses.... | 27·73 | 27·84 | 27·81 |

It will be observed that hydrofluoric acid has removed some silica, but still the percentages are higher than the theory. We should infer, therefore, that quartz is an impurity in the mineral and that it is present as very minute inclusions. If, for example, the inclusions are as fine or finer than the acicular crystals of rutile in quartz, they could not be removed by a specific gravity separation, nor, being enclosed in the staurolite, would they be wholly accessible to the action of hydrofluoric acid. That the formula suggested by Groth is correct is well established by our analyses and, surely, its simplicity is one of the strongest arguments that can be advanced for its acceptance.

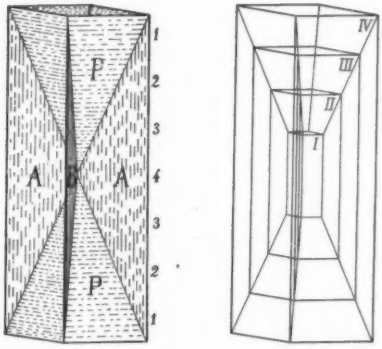
*On the regular arrangement of inclusions in staurolite crystals.*—In examining orientated thin sections of crystals from Lisbon, N. H., it was observed that they all contained dark inclusions, arranged in certain definite planes, resembling the phenomena so common in andalusite. That the inclusions are carbonaceous material was proved by the fact that, on separating the pulverized mineral by specific gravity, the dark portion was found to be lighter than the clear staurolite, and on igniting it in a current of air, purified by passing over caustic potash, carbon dioxide was abundantly evolved. These inclusions can only be clearly seen in plates ground sufficiently thin to be transparent and can best be studied in basal sections.




Figures 1 to 4 represent the arrangement of the inclusions in plates cut from a simple prismatic crystal 50$^{mm}$ in length by 11$^{mm}$ broad from which eleven basal sections were cut. Near the ends the impurities are arranged as in fig. 1; at the middle

the appearance is that of a simple dark cross, fig. 4; while intermediate sections show the rhomb diminishing in size as the sections approach the middle of the crystal, figs. 2 and 3. A number of crystals were cut showing this same phenomena and the symmetrical arrangement of the rhomb and cross was always well marked. The central portions *a* and the outer ones *b*, up to the very edges of the section, are remarkably pure staurolite. The dark bars running parallel to the macro axis broaden as they approach the outer angle of the section and are more regular and better defined than the brachy-diagonal ones. From a series of sections, then, it is evident that each staurolite prism contains two skeleton or phantom pyramids P, outlined by carbonaceous material, whose bases correspond to the basal planes of the staurolite and whose apices join at the center, while from the acute and obtuse pole edges of the

5. 6.




pyramids the inclusions extend as films or fins A and B to the vertical edges of the prism, fig. 5, the numbers at the side of the figure indicating where sections should be cut to give the phenomena corresponding to figures 1 to 4 respectively. Regularly arranged inclusions have previously been observed in staurolite* but apparently they have never been studied from a series of sections from a single crystal.

In seeking for an explanation of these inclusions, it must be borne in mind that staurolite is a mineral occurring essentially in the crystalline schists, which were probably derived from former mud or clay deposits. The crystals were formed by metamorphic agencies, under great pressure, in rocks which

* C. T. Jackson, Alger's Phillips Mineralogy, 1844, p. 112; Dana's Min., Sixth edition, p. 560; S. Webber, Proc. Nat. Institution for the Promotion of Sci., Bull. 2, p. 197, 1842; A. Lacroix, Min. de la France, 1893, p. 11.

were probably quite firm and solid while the staurolite was forming. The crystals, therefore, must have exerted great force in crowding away the surrounding rock material in order to make room for their growth, and we must take into consideration their inability to exclude foreign matter under these conditions, as well as their tendency to take it up. Large crystals have surely resulted from a growth about smaller ones and the beginnings of the crystals under consideration were undoubtedly at the centers, where the apices of the pyramids P, fig. 5, join. In the development of a large crystal from a small one it is imagined that at various points on the crystal faces the growth commences. The addition of particles or of crystal molecules must then advance, forcing foreign matter to one side until the crystal surfaces are complete. The particles, however, which meet to form the edges of the crystals may come together in such a way that they cannot exclude certain foreign materials. It would, moreover, seem reasonable to expect that the more obtuse the angle at which the faces, or the crystal molecules forming the faces, meet to form an edge, the less tendency there would be to hold impurities, while the more acute the edge the greater this tendency would become. If these conclusions are correct, then inclusions would be taken up by the edges, and being largely of carbonaceous material, as in the staurolite under consideration, the result would be that, in the development of a large crystal from a smaller one, the inner prism I, fig. 6, as it enlarged to form II, III and IV, would leave a dark deposit along the paths described by its advancing edges, corresponding to the planes A, B and P of fig. 5. In examining many basal sections it has, moreover, been generally observed that the bars running parallel to the macro-axis, representing the impurities taken up at the acute edges of the prism, are the heaviest, those parallel to the brachy axis are the lightest and in some sections practically fail, while the outlines of the inner rhomb, representing the impurities taken up along the edges of 90° between prism and base, are intermediate as regards the quantity of included matter. Also the inclination of the phantom pyramid P, fig. 5, seems to be wholly dependent upon the relative development of the prism and base during the growth of the staurolite crystal and to be in no way connected with the length of the vertical axis as expressed by the axial ratio $\breve{a} : \bar{b} : \dot{c}$.

The considerations given above seem sufficient to account for the curious arrangements of the impurities in the crystals under consideration and doubtless by a similar explanation the impurities in some andalusite crystals could be accounted for.

Laboratory of Mineralogy and Petrography,
Sheffield Scientific School, November, 1893.

ART. VIII. — *The Carboniferous Insects of Commentry, France;* by SAMUEL H. SCUDDER.

ALTHOUGH only a very few fossils have yet been fully described or figured from Commentry it has been known for some years that it is the richest locality for paleozoic insects yet discovered. Commentry lies in central France, in the Department of Allier and the horizon is Upper Carboniferous. Mining is there carried on in the open air and this offers the best possible opportunity for recognizing and preserving the fossils.

Besides some brief notices of the richness of the insect fauna at Commentry and the description of some highly remarkable forms, M. Charles Brongniart of the Paris Museum, to whose hands all the material has been entrusted, published a few years ago a summary notice of the entire collection, which, without entering into details, indicated at once the astonishing variety and abundance of forms at this locality.

Within the last two or three days I have had the opportunity through the kindness of M. Brongniart of seeing not only a considerable part of this collection but also the illustrations prepared by M. Brongniart himself from the choicest specimens; illustrations made with a care and exactitude which leave nothing to be desired, and which are now nearly completed after a labor of ten years, so that we may hope soon to be favored with his final work. Leaving the cockroaches out of account, to which M. Brongniart will give his attention later, the number of these illustrations, their variety, the extraordinary character of the insects themselves and their rare perfection, leave not the least room for doubt that when his work appears, our knowledge of paleozoic insects will have been increased three- or fourfold at a single stroke and an entirely new point of departure for the future opened. No former contribution in this field can in any way compare with it, nor even all former contributions taken together. Besides it will offer such a striking series of strange forms as cannot fail to awaken the attention of the least incurious. One may not enter into details, but mention may simply be made of one species, regarded by M. Brongniart as one of the forerunners of the dragon flies, in which the wings have an expanse of considerably more than two feet (or about 70 centimeters) and of which several specimens are preserved. It is a veritable giant among insects.

Paris, Dec. 2, 1893.

ART. IX.—*On the Cæsium-Cupric Chlorides;* by H. L. WELLS and L. C. DUPEE.

As a continuation of the work done in this laboratory on double halogen salts, we have taken up the cæsium-cupric chlorides, which had never been thoroughly investigated. The result has been the discovery of four double salts belonging to three different types. The beauty of the crystals in size and form, and the magnificent and unexpected colors of some of them have made the investigation a very interesting one. The colors of the anhydrous salts, yellow and red, were perhaps not very remarkable since anhydrous cupric chloride is reddish brown, but since water of crystallization is supposed to give green and blue colors to cupric salts, we were considerably surprised to find that a brown salt, $Cs_3Cu_2Cl_7 . 2H_2O$, was hydrous. The color of this hydrous salt is, however, not without analogy, for a garnet-red, hydrous lithium-cupric chloride is known, $LiCuCl_3 . 2\frac{1}{2}H_2O$ according to Chassevant,* or $LiCuCl_3 . 2H_2O$ according to Meyerhoffer;† moreover Engel has described‡ a garnet-red compound $HCuCl_3 . 3H_2O$, and Sabatier's red salt $H_2CuCl_4 . 5H_2O$,§ is similarly exceptional in color.

In this connection, it should be noticed that cupric chloride, when dissolved in water with an excess of cæsium chloride gives a bright yellow solution when it is hot and concentrated. It is well known that solutions of cupric chloride in concentrated hydrochloric acid have the same yellow color.

A list of the formulæ of the salts to be described, with their colors, is given below. The first salt has already been described by Godeffroy.‖

| | |
|---|---|
| $Cs_2CuCl_4$ | Brilliant yellow. |
| $Cs_2CuCl_4 . 2H_2O$ | Bluish green. |
| $Cs_3Cu_2Cl_7 . 2H_2O$ | Brown. |
| $CsCuCl_3$ | Garnet-red. |

The previously described cupric double halides containing alkali-metals and ammonium belong to two of the types which we have found in investigating the cæsium-cupric chlorides. A list of all those that we have been able to find is given below. Four of the double fluorides have been recently described by von Helmont.¶

* Compt. Rend., cxiii, 646.
‡ Compt. Rend., cvi, 273.
‖ Berichte, viii, 9.
† Monatshefte, xiii, 716.
§ Compt. Rend., cvi, 1724.
¶ Zeitschr. Anorgan. Chem., iii, 115.

| 2 : 1 Type. | 1 : 1 Type. |
|---|---|
| $(NH_4)_2CuCl_4 . 2H_2O$ | $NH_4CuCl_3 . 2H_2O$ |
| $K_2CuCl_4 . 2H_2O$ | $NH_4CuF_3 . 2\frac{1}{2}H_2O$ |
| $K_2CuF_4$ | $KCuF_3$ |
| $(NH_4)_2CuF_4 . 2H_2O$ | $RbCuF_3$ |
| | $LiCuCl_3 . 2H_2O$ |

It is to be noticed that this list contains salts which correspond exactly to three of the cæsium compounds, and that the group of 2 : 1 salts with two molecules of water is a conspicuous one.

The salt $Cs_3Cu_2Cl_7 . 2H_2O$ is an interesting one because it is apparently the only known double halide of an alkali metal with a bivalent metal, which has the 3 : 2 ratio.

The cæsium salts were investigated systematically by starting with a solution of 50 g. of cæsium chloride and adding to this from 3 to 5 g. of cupric chloride at a time, evaporating after each addition and observing the products. At the same time another series of experiments was made by beginning with a solution of 50 g. of cupric chloride, adding cæsium chloride to this gradually and operating in the same manner as in the other case. Many additional experiments were made, sometimes with the use of as much as 200 g. of cæsium chloride, and a number of crystallizations were made in the presence of hydrochloric acid of various strengths. It is believed that no double salt capable of existence either in warm solutions or at ordinary temperatures has been overlooked.

The salts were so well crystallized and so distinct in form and color that there was no difficulty in selecting pure products for analysis. The usual precautions, often mentioned in communications from this laboratory, were taken for the removal of mother-liquor from the crystals.

In analyzing the salts copper and cæsium were determined in one portion, the first as subsulphide, the other as normal sulphate. The chlorine was determined in separate portions, by the usual gravimetric method.

*Anhydrous 2 : 1 Cæsium-Cupric Chloride, $Cs_2CuCl_4$.*:—This salt, which Godeffroy first described, forms magnificent, yellow, orthorhombic prisms, which were often obtained several centimeters in length and several millimeters in thickness. The crystals are usually attached at one end, and they often arrange themselves in parallel position, forming flat clusters. Doubly terminated, short crystals were occasionally observed. Its formation was observed, with 50 g. of cæsium chloride, in the presence of from 5 to about 25 g. of cupric chloride. It can be recrystallized from water if the solution is made so concentrated that crystals form on cooling,

but with more dilute solutions one or both of the hydrous salts are usually deposited on standing or on spontaneous evaporation. The following analyses represent different crops made under considerable differences of conditions:

| | | Found. | | | Calculated for $Cs_2CuCl_4$. |
|---|---|---|---|---|---|
| Cs | ----- | 56·33 | 56·14 | 56·18 | 56·42 |
| Cu | 13·52 | 13·45 | 13·47 | 13·48 | 13·46 |
| Cl | 30·07 | 29·99 | 30·04 | 30·03 | 30·12 |
| | | 99·77 | 99·65 | 99·69 | 100·00 |

*Hydrous 2:1 Cæsium-Cupric Chloride, $Cs_2CuCl_4 . 2H_2O$:* —This salt is bluish green in color, and it loses its water very rapidly on exposure to the air with a change of color to bright yellow. It is a well crystallized, transparent salt, but its form was not made out on account of its instability. It is difficult to prepare it, at least at summer temperatures under which this investigation has been made, and we have only occasionally observed it. It is formed by allowing solutions containing nearly the required proportions of cæsium and copper chlorides to evaporate spontaneously. A sample quickly pressed on paper gave the following analysis:

| | Found. | Calculated for $Cs_2CuCl_4 . 2H_2O$ |
|---|---|---|
| Cæsium | 51·28 | 52·40 |
| Copper | 12·53 | 12·50 |
| Chlorine | ---- | 28·00 |
| Water | 7·20 | 7·10 |

Another sample, which had been exposed to the air too long, gave 6·02 per cent of water, and the dehydrated compound gave the following analysis:

| | Found. | Calculated. |
|---|---|---|
| Cæsium | 56·09 | 56·42 |
| Copper | 13·68 | 13·46 |

*3:2 Cæsium-Cupric Chloride, $Cs_3Cu_2Cl_7 . 2H_2O$:* — This compound was obtained from solutions of nearly the required proportions of cæsium and cupric chlorides. It usually forms only at ordinary temperatures, and if the solution is too concentrated, one or both of the anhydrous salts will be deposited while it is warm. The salt forms triclinic crystals, often one or two centimeters in diameter. The large crystals are deep brown in color, small ones and fragments are very much paler while the powder is yellow. It is nearly stable at ordinary temperatures, but gradually loses its luster on long exposure. All the water goes off readily at 100°. The following analyses of separate crops were made:

| | | Found. | | Calculated for $Cs_2Cu_2Cl_7 . 2H_2O$. |
|---|---|---|---|---|
| Cæsium | ---- | 49·36 | 48·96 | 49.23 |
| Copper | 15·68 | 15·90 | 15·74 | 15·67 |
| Chlorine | 30·84 | 29·90 | 30·69 | 30·66 |
| Water | 4·22 | 4·38 | 4·41 | 4·44 |
| | | 99·54 | 99·80 | 100·00 |

*1 : 1 Cæsium-Cupric Chloride, $CsCuCl_3$ :*—This is formed under wide variations of conditions, up to the point where the solution is saturated with cupric chloride. It can be recrystallized from water. It forms slender hexagonal prisms terminated by pyramids. The color is a deep garnet-red, and all except very slender crystals appear black by reflected light. The following analyses of separate products were made:

| | | Found. | | Calculated for $CsCuCl_3$. |
|---|---|---|---|---|
| Cæsium | 43·67 | ----- | 43·58 | 43·89 |
| Copper | 21·16 | 21·17 | 21·06 | 20·96 |
| Chlorine | 35·25 | 35·22 | 35·00 | 35·15 |
| | 100·08 | | 99·64 | 100·00 |

Sheffield Scientific School, September, 1893.

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## Art. X.—*On the Cæsium-Cupric Bromides;* by H. L. Wells and P. T. Walden.

We have made a systematic investigation of the cæsium-cupric bromides, following the plan, described in the preceding article, which was used for the corresponding chlorides. Although the work has been very thorough, we have found only the following two salts:

$$Cs_2CuBr_4 \text{ and } CsCuBr_3.$$

These salts correspond to the two common types of cupric double halides. The fact that no hydrous salts could be obtained was unexpected, because it has been pointed out by Remsen* in the case of certain double halides, and it has been observed by one of us in the case of the alkaline-lead halides,† that the tendency to combine with water seems to increase with the atomic weight of the halogen. The fact that hydrous

* Am. Chem. Jour., xiv, 88. † This Journal, xlvi, 37.

double chlorides of cæsium and copper exist, while no corresponding bromides were obtained indicates that the rule does not apply in all cases.

*2 : 1 Cæsium Cupric Bromide, $Cs_2CuBr_4$ :*—This compound forms opaque, black crystals having a greenish tint. The powder is black. In form and habit it resembles the corresponding chloride and is evidently orthorhombic like that salt. Elongated prisms, usually not over 5 to 10$^{mm}$ in length, commonly occurring in groups in parallel position, were observed where an excess of cæsium bromide was used. When the proportion of cupric bromide was increased, small short crystals made their appearance.

With 50 g. of cæsium bromide the compound is formed in the presence of from 5 to about 70$^g$ of cupric bromide. The range of conditions under which it is formed are considerably wider than in the case of the corresponding chloride.

Of the analyses given below, A, B, C, D and E represent a series of preparations in which copper bromide was gradually increased from 5$^g$ in A to 46$^g$ in E, while the cæsium bromide remained constant at about 50$^g$ and the volume increased from 100$^{cc}$ in A, to 150$^{cc}$ in E. The sample F was obtained by recrystallizing the salt from water, while G resulted from recrystallizing $CsCuBr_3$.

| | Cs. | Cu. | Br. |
|---|---|---|---|
| A | 40·80 | 9·46 | 49·38 = 99·64 |
| B | ---- | 9·68 | ---- |
| C | 40·75 | 9·74 | 48·97 = 99·46 |
| D | 40·88 | 9·69 | 48·95 = 99·52 |
| E | ---- | 9·78 | 49·40 |
| F | 41·11 | 9·66 | ---- |
| G | ---- | 10·00 | ---- |
| Calculated for $Cs_2CuBr_4$ | 40·96 | 9·77 | 49·27 = 100·00 |

*1 : 1 Cæsium-Cupric Bromide, $CsCuBr_3$.*—This salt forms short, hexagonal crystals which are strung together end to end. They are dark and opaque, giving a bronze-colored reflection, while their powder is nearly black. When recrystallized from water the compound gives the 2 : 1 salt, thus differing from the chloride. It was obtained from a solution containing 50$^g$ of cæsium bromide and 70$^g$ of copper bromide with sufficient water to form a volume of 200$^{cc}$, and it continued to be produced as cupric bromide was added until the solution became saturated with that compound.

The following analyses were made of separate preparations which were obtained under wide variations of conditions.

| | Found. | | | | Calculated for $CsCuBr_3$. |
|---|---|---|---|---|---|
| Cs ..... | 29·93 | 29·09 | ---- | 30·43 | 30·48 |
| Cu..... | 14·72 | 15·09 | 14·73 | 14·81 | 14·53 |
| Br ..... | 55·09 | 54·96 | ---- | 64·96 | 54.99 |
| | 99·74 | 99·14 | | 100·20 | 100·00 |

Sheffield Scientific School, September, 1893.

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ART. XI.—*On the Cæsium-Cuprous Chlorides;* by H. L. WELLS.

THE salts to be described were prepared by heating solutions containing cæsium chloride and cupric chloride with copper wire, and sufficient hydrochloric acid to prevent the formation of basic salts; then, after the copper in solution was chiefly in the form of cuprous chloride, cooling to crystallization.

When the solutions were dilute, cæsium chloride being in in excess, very slender white prisms were obtained under wide variations of conditions. The crystals became yellowish while being dried with paper, but they were apparently nearly stable in the air when dry. It was found that the salt was decomposed by water. Two different products were analyzed.

| | Found. | | Calculated for $CsCl \cdot Cu_2Cl_2$. |
|---|---|---|---|
| Cæsium ..... | 36·93 | 36·36 | 36.29 |
| Copper ..... | 34·33 | 34·17 | 34·64 |
| Chlorine ..... | 28·95 | 28·87 | 29·07 |

The results show that the formula $CsCu_2Cl_3$ belongs to this salt.

On using more concentrated solutions, also with an excess of cæsium chloride, thin, rectangular, colorless plates were produced, sometimes 10 or 20$^{mm}$ in diameter. The range of conditions under which this salt is produced is wide, and large crops of it are easily prepared. As the concentration of the cæsium chloride solutions was increased the same compound appeared in the form of blade-like crystals with pointed ends. By dissolving this salt in water the previously described compound is produced by crystallization. The surface of the crystals becomes yellow on drying, but when dry it appears to be very stable. The first two analyses represent separate crops of the rectangular plates, the third a crop of the blade-like crystals.

| | Found. I. | II. | III. | Calculated for $3CsCl . Cu_2Cl_2$. |
|---|---|---|---|---|
| Cæsium ..... | 56·81 | 56·66 | 56·84 | 56·72 |
| Copper ..... | 17·95 | 17·89 | 17·84 | 18·05 |
| Chlorine .... | 25·03 | 25·08 | 25·13 | 25·23 |

It is evident that this salt has the formula $Cs_3Cu_2Cl_5$.

With nearly or quite saturated cæsium chloride solutions containing comparatively little cuprous chloride, prismatic crystals are formed on cooling. The crystals are very pale yellow in color and their luster is less brilliant than that of the preceding compound. Crystals having a diameter of two or three millimeters and a length of several centimeters were sometimes observed. This salt forms under very narrow limits of conditions and it is very difficult to obtain it free from the preceding salt, and especially from cæsium chloride which usually crystallizes with it when the conditions are right for its formation. After a great many trials three crops which were satisfactory were obtained for analysis. The third analysis represents crystals which were picked out of a solution one at a time and separately pressed between smooth filter-papers. All the preparations were carefully examined under the microscope and were evidently pure.

| | Found. | | | Calculated for $6CsCl . Cu_2Cl_2 . 2H_2O$. |
|---|---|---|---|---|
| Cæsium ..... | 64·77 | 65·07 | 64·09 | 64·10 |
| Copper ..... | 9·38 | 9·42 | 10·04 | 10·20 |
| Chlorine ..... | 22·70 | 22·83 | .... | 22·81 |
| Water (difference) | 3·15 | 2·69 | 3·14 | 2·89 |

The analyses show that the salt has the formula $Cs_3Cu Cl_4 . H_2O$.

The previously described cuprous double halogen salts, with the new cæsium salts for comparison, are given below:

| Cæsium Salts. | Previous Salts. |
|---|---|
| $CsCl . Cu_2Cl_2$ | $4NH_4Cl . 3Cu_2Cl_2$ |
| $3CsCl . Cu_2Cl_2$ | $2NH_4I . Cu_2I_2 . H_2O$ |
| $6CsCl . Cu_2Cl_2 . 2H_2O$ | $4KCl . Cu_2Cl_2$ |
| | $4NH_4Cl . Cu_2Cl_2$ |

It is remarkable that there is no correspondence in type between the cæsium compounds and the others, and that such a variety of types appears to exist. The formula $4NH_4Cl . 3Cu_2Cl_2$ may be considered somewhat doubtful on account of its complex ratio, and because with one-fourth less ammonium chloride it would correspond to the first cæsium salt.

The salt $Cs_3Cu_2Cl_5$ is noticeable on account of its rather complex formula and because it has the same ratio of cæsium to

copper as the previously described cupric salt $Cs_3Cu_2Cl_7 . 2H_2O$. Since the latter has a ratio that is unique among the bivalent metal double halogen salts, a close structural relation between the two compounds is suggested.

These cæsium-cuprous chlorides show a decided lack of conformity with Remsen's law* concerning the composition of double halides. Two out of three of them fail to correspond to the law, while one of these, instead of not containing more than one CsCl for one CuCl, actually contains three times as much cæsium chloride as Remsen's law allows.

My thanks are due to Mr. L. C. Dupee, who prepared and analyzed one sample of the salt $CsCu_2Cl_3$

Sheffield Scientific School,
New Haven, Conn., September, 1893.

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## Art. XII.—*The Harrisburg Terraces;* by Harvey B. Bashore, West Fairview, Pa.

In 1889 I began a study of the gravel deposits at Harrisburg, Pa.; at the suggestion of Prof. G. F. Wright, I made special effort to discover, if possible, some facts which might be of value in settling the much-debated question as to the origin of the deposits in this valley; and I shall, in this paper, confine myself to the statement of facts only, leaving all theorizing to others.

The river at this point flows between high slate hills, the distance between which is generally one mile but in the neighborhood of Harrisburg the interval is increased to a mile and a half, and this additional one-half mile, on the eastern side has been filled by successive deposits of gravel and clay, forming the plane for the building of the city of Harrisburg.

The deposit, which is about one-half a mile wide and between two and three miles long, consists of four terraces, differing somewhat in their characteristics: it is necessary, therefore, to describe each separately. The first and lowest terrace is about 28 feet above low water (river 290 A. T.): it is composed of a fine brick-making clay and contains many bowlders of large size (4–5 feet in diameter), mostly of local origin, composed of sandstone and conglomerate from the mountains beyond; this deposit is distinctly marked on both sides of the river and forms the gradient for the public highways: in most cases, too, it is the bed of the railways up and down the river.

* Am. Chem. Jour., xi, 296; xiv, 85.

The second terrace, 46 feet above the river, is not very plainly marked: one of the city streets however was originally graded from its level. The bed is composed of gravel, some granite and gneiss,* and contains large and small bowlders all rounded, and is capped by two or three feet of fine loam.

The third terrace, 90 feet above the river forms the plane for two of the city streets (Fifth and Sixth). This deposit, which gives a good perpendicular exposure of 15 feet, is composed of fine gravel and contains some granite and gneiss; a few rounded bowlders, two to three feet in diameter appear in it and the whole deposit is capped by four or five feet of fine clay: almost all the bowlders occur in the gravel.

The three terraces just described are placed in the interval between the river and the hill, but the highest or fourth terrace is situated on the brow of the hill itself.

The fourth terrace, 130 feet above the river—420 A. T.—is well exposed by the cutting of several streets and shows the gravels resting upon the slate. The deposit is about 20 feet thick and is capped by fine brick clay. The gravel bed, especially at its upper part, presents a peculiar white appearance compared to the overlying clay—the line of junction between the gravel and clay being very distinctly marked. The gravel contains considerable quartz, some granite and gneiss pebbles, but none were found more than two or three inches in diameter; some rounded bowlders, two to three feet in diameter occur in the deposit, mostly in the gravel, although several were found in the clay. Above this joint, 420 A. T., on the eastern side of the river there was not found any further evidence of water action although careful search was made over the adjoining hills: on the western side, however, as I stated in a former report to the State Geologist of Pennsylvania, I found, on a slate hill at 148 feet above the river, a number of small rounded pebbles, one of which was of gneiss; it is possible, however, that their transportation was due to human agency. I may add that the mountains both north and south of the city were carefully searched for "shore-lines" but the result was negative in every instance.

West Fairview, Pa., Nov. 1, 1893.

* Granite and gneiss do not occur in the Susquehanna Valley above this point except as transported rock from regions farther north.

## Art. XIII.—*Additional Species of Pleistocene Fossils from Winthrop, Mass.;* by Richard E. Dodge.

Any note concerning the discovery of additional species of shells in the drift of the last Glacial period is interesting because we thus obtain a fuller conception of the richness and distribution of the oceanic fauna previous to the advent of the ice sheet. For that reason, I venture to note here the finding of a few additional species in the drumlin in Boston Harbor, locally known as Winthrop Great Head. This drumlin is the most important of several in Boston Harbor that have furnished fragments of shells, from time to time, for of the twenty-six species thus far found, it has given us twenty-three, and the others together but three. Furthermore only three of the species found in this locality have been found in the other drumlins of the harbor.

The first note of the finding of fragments of shells, in more or less perfect condition, in the clayey till of Winthrop Great Head was made by Dr. Stimpson,* who reported the following species: *Balanus crenatus* Brugière, *Chrysodomus decemcostatus* Say, *Tritia trivitatta* Adams, *Urosalpinx cinerea* Stimpson, *Mya arenaria* Linné, *Ensatella americana* Verrill, *Mactra solidissima* Chemnitz, *Venus mercenaria* Linné, *Cyclocardia borealis* Conrad, *Astarte undata* Gould, *Astarte castanea* Say, *Mytilis edulis* Linné, *Modiola modiolus* Turton, *Ostrea virginiana* Lister. In 1888 Mr. W. W. Dodge† reported the finding of species of the genera *Lacunea*, *Tapes*, and *Cardium*. In 1888 Mr. Warren Upham, in a paper before the Boston Society of Natural History,‡ from which the above list has been taken, reported *Cliona sulphurea* Verrill, from the same locality.

So far as I can find out, these are the only species reported from this locality up to the present time. Other drumlins in the harbor have furnished occasional specimens of the following additional species: *Lunatia heros* Adams, *Saxicava arctica* Deshayes, *Pecten islandicus* Chemnitz.

Of the specimens mentioned above, the only ones that are at all common in the drift are *Venus mercenaria*, *Cyclocardia borealis* and *Cliona sulphurea*. The other specimens are rare and very fragmentary, so that identification is frequently difficult if not impossible.

To the above list I wish to add the following, which I have been fortunate enough to find during recent short trips to the

* Proc. Bost. Soc. Nat. Hist, vol. iv, p. 9.
† This Journal, III, vol. xxvi, p. 56, July, 1888.
‡ Proc. Bost. Soc. Nat. Hist., vol. xxiv, pp. 127–141.

cliff at Winthrop: *Lunatia groenlandica* Stimpson, *Scapharca transversa* Adams, *Buccinum undatum* Linné, *Ilyanassa obsoleta* Stimpson. Of the above, all but the last are undoubtedly new discoveries. The last has however been noted by Verrill* as coming from this locality, having been discovered by Dr. Stimpson. I have examined all the references I could find to discover where Dr. Stimpson has announced the finding of the species, but without success. Even in the article,† in which he changes the generic name from Nassa to *Ilyanassa*, he makes no mention of its occurring as a fossil either in this locality, or anywhere along the shore of Massachusetts Bay.

I have also found a small fragment of shell, the species of which I have thus far been unable to have determined. Prof. Verrill, to whom the specimen was referred for identification, states in a letter, "I have compared it with all similar living shells of our Eastern Coast fauna and find nothing just like it in sculpture. It probably belongs to the *Veneridæ* or *Lucinidæ*, but there is too little of it to be sure even of the family. It may be Tertiary or even Cretaceous, for I have had specimens of soft limestone bowlders from the drift of Cape Cod containing well preserved Cretaceous shells." Mr. J. B. Woodworth has shown me some specimens which he has collected from the Miocene of Squibnocket, Martha's Vineyard, which this fragment resembles in a marked degree. If this species should prove to be not now known on the Atlantic seaboard, it would be the first instance, as far as I know, of a species found as a fossil in the Glacial drift but not now living. Mr. Upham says:‡ "All these species which remain from the marine fauna that existed before the formation of the last ice sheet, are found living at the present time in the adjoining waters of Massachusetts Bay." *Venus mercenaria* however is more truly a southern form and is only found scatteringly in the Bay. It is thus very similar in its distribution to *Scapharca transversa*, which is not found north of Cape Cod. Finding thus this species as a fossil in Massachusetts Bay, which now lives only in the warmer waters south of Cape Cod, we have a strong bit of additional evidence to help prove that the waters of Massachusetts Bay, just previous to the advent of the last ice sheet, were somewhat warmer than at present, an hypothesis which is now pretty generally conceded to be true.

Recent discoveries of Post-glacial fossils from dredgings in Boston Harbor, noted by Mr. Upham,§ show us conclusively

* Report upon the Invertebrate Animals of Vineyard Sound, U. S. Fish Commission Report, 1871–72.

† Am. J. Conchol., vol. i. p. 61.

‡ Proc. Bost. Soc. Nat. Hist., vol. xxiv, p. 134.

§ Proc. Bost. Soc. Nat. Hist., vol. xxv, pp. 305–316.

that the waters immediately at the close of the Glacial period were warmer than at present. Of twenty-five species thus far reported from the dredgings, many of which are the same as in the Glacial drift, fourteen are distinctly southern in their distribution, according to Mr. Upham. Thus, as far as we can determine by the testimony of fossils, the ocean waters of Cape Cod both immediately before the advance of the ice sheet and just after the retreat were warmer than at present. Whether these changes in temperature were due to the presence or absence of melting glaciers in the neighboring oceanic waters or whether they were due to slight oscillations of land, it is difficult to determine. The existence of elevated shore lines and fossiliferous clays to the north of Massachusetts Bay, noted by Prof. Shaler and others, would seem to show that the changes of temperature were due to oscillations of the continent which at one time gave access to the warmer southern waters into Massachusetts Bay, and at others shut them out more than at present.

Inasmuch as the direction of ice movement during the drumlin-making stage must have been from a generally northwesterly direction in this region, as shown by the striæ, the fragments of shells now found in the drumlins must have occupied a position, at the beginning of the ice advance, somewhere to the northwest of the spot where they are now found, otherwise they could not have been taken up and carried by the ice in such a manner as to be deposited in their present position. As I have already stated, all these species of fossils but two are now found living in the waters of Massachusetts Bay, and if the necessary conditions for their existence have always been the same, it would appear that, at the time the ice sheet overrode this portion of the coast, there must have been somewhere in the western portion of Boston Harbor, probably near the present estuary of the Charles River, an extensive colony of shells of many different species. Yet we find no evidence, other than the shells themselves, of the existence of any such colony of invertebrates, in the localities I have noted. It would seem very strange however that all the more important discoveries of pleistocene fossils from the drift of this region have been from one drumlin, while the several drumlins in the immediate vicinity have furnished but a very few species. It is especially difficult to understand why we find but four different species of fossils in the large drumlin, called Grover's Cliff, about a mile to the northeast of Winthrop Great Head, while Great Head itself has given us twenty-three species.

It would seem furthermore as if the distance of travel which these fragments underwent must have been considerable,

and this for the reason that they are found in the eroded face of the drumlin often at a height of over fifty feet above the present sea level. Even if dead they would not probably have been elevated much above the present level of the sea in their original resting place, when set in motion by the ice sheet, and a somewhat lengthy journey in the ice would seem requisite in order to allow them to have risen so high above sea level as we now find them. In spite however of the long journey, apparently necessary for elevation in the ice, the fragments, with few exceptions, show little evidence of Glacial wear. Mr. J. B. Woodworth has shown me two small fragments of *Venus mercenaria* from the Winthrop Great Head cliffs that still present faint glacial striæ on the inside, yet the shells have not been sufficiently worn to lose their surface markings or the gloss of the interior. The specimens of *Buccinum* and *Ilyanassa* are especially well preserved, being but slightly worn at the apex of the spire and retaining their delicate surface markings.

I found each of these two shells filled with compact till containing small pebbles, and in one case a fragment of the shell of *Venus mercenaria*. If the shell had died in place previous to being taken up by the ice, it might be reasonably expected to retain in its chamber, even to the present time, some of the bottom on which it had lived. Therefore I carefully removed the filling from the outer chamber of the *Buccinum* but failed to find within any other material than clayey till like that in which it was lying when found.

The large number of small fragments of shells scattered through the till in the lower half of the drumlin of Winthrop Great Head would seem to indicate that much of the material of which the drumlin is composed came from the same place as the shells, for we cannot conceive how the onward moving glacier could remove the shells without taking at the same time a large part of the bottom on which the shells were growing. If so, then the materials of this drumlin and of much of our drift, not only represents the amount of bed rock removed by the ice sheet, but such rock waste plus a large amount of the previously accumulated soil, river and shore deposits. It may in this case even include much of the drift deposited by the first ice epoch which has been undergoing secular decay during all of interglacial times. At any rate the physical character of the material in the face of this drumlin seems to indicate the presence of much fine clayey matter, greatly decayed and appearing very similar in nature to the brick clays of Cambridge and Somerville, Mass. These brick clays on fresh exposure present to view innumerable small vertical joints which allow the clay to break up into small cubes. This tendency to break along incipient joint planes appears much

more conspicuously in the clays of the drumlins of Boston Harbor than in any of the inland drumlins I have had an opportunity to note in Western Massachusetts and Connecticut. The possible presence of such a large amount of previously eroded material in the deposits laid down during the last stages of the ice age relieves us from considering that a moving continental ice sheet is such a great erosive agent as we are wont to believe it.

Mr. W. O. Crosby,* believes that "possibly as much as one-fourth and quite certainly not more than one-third of the detritus composing the till of the Boston basin was in existence before the ice age, and that the remaining two-thirds or three-fourths must be attributed to the mechanical action of the ice-sheet and its accompanying torrents of water." Comparing this estimate of the amount of erosion by the ice sheet in Boston Harbor with the scant amount of work done by the ice sheet in Western Massachusetts and Connecticut, as shown by the very conspicuous bed rock topography formed in preglacial times and but little affected by the ice advance, the estimate seems to be very large indeed.

The most interesting problem suggested by the presence in our drift of such fossil fragments as I have described is, however, that of the relative positions of land and sea in the different epochs of pleistocene times. For that reason, even the evidence of one small fragment like that of *Scapharca transversa* is important, though it gives us but one small bit of proof of the warmer waters in Massachusetts Bay in the times immediately previous to the last ice age. It only remains in conclusion to say that similar assemblages of pleistocene shells have been found in our glacial drift in other localities, but mainly on the southern shores of New England. The most important discoveries have been those of Desor† and Verrill and Smith‡ from the apparently interglacial beds of Sankaty Head, Nantucket. At this locality more than a score of species have been found, occurring in two distinct beds. The lower beds contain warm water forms and the upper mostly worn fragments of northern forms. On our northern shores no section so rich in pleistocene fossils has as yet been found as that of Winthrop Great Head, although similar deposits have been found by Prof. Shaler at Gloucester, Mass., and by others at different localities on the coast of Maine. The reason for the occurrence of so many different species of fossils in this one drumlin in Winthrop, situated as it is among so many neighboring unfossiliferous drumlins, still remains a mystery.

Harvard University, Cambridge, Mass.

* Proc. Bost. Soc. Nat. Hist., vol xxv, p. 115–140.
† Quar. Jour. Geol. Soc. Lond., vol v, pp. 340–344.
‡ This Journal, III, vol. x, 1875, pp. 364–370.

ART. XIV.—*The Amount of Glacial Erosion in the Finger-lake Region of New York;* by D. F. LINCOLN, M.D., Geneva, N. Y.

[Read before the Am. Assoc. for the Advancement of Science, Madison, August, 1893.]

THE Lake-region proper does not extend beyond the Devonian belt; it will, however, be instructive to include in our consideration the closely-related "drumlin-belt" of level country adjacent on the north, which covers the upper Silurian area between Rochester and Syracuse, nearly. Within this region occurs the well-marked, though low, Corniferous escarpment, besides some local escarpments to the south: the Niagara exposures being hardly worthy of that name. Most of the formations are exposed at great numbers of points in brooks, and complete sections across the Devonian are afforded by some of the lakes. Beginning at the north, the formations in ascending order are as follows:*

The Medina sandstone along Lake Ontario is thickly enveloped with drift and lake deposits. Five exposures in the beds of brooks are mentioned by Hall in Wayne County. (Report for the Fourth District, 1843). In the Clinton shales and limestone Hall names twelve exposures, adding that "almost every stream north of the road from Wolcott to Rochester exposes one or more members of this group." The Niagara shale is soft, and forms very gentle slopes. It is exposed, though not deeply cut, in "all the small streams which flow into the lake" (Hall).

The Niagara limestone occupies a tract a mile or two wide, crossing the middle of the lake counties from west to east. Its position is marked by a line of lime-kilns across the country. Little cascades or rapids occur wherever the streams pass from it to the shale. It is characterized by frequent low anticlines, with axis approximately N.–S., the backs of which come within a foot or two of the surface. Broad levels, underlain by sheets of this rock, with only a foot or two of soil, have been observed at Sodus. On the whole, the contour of the landscape is not distinctly affected by this formation.

The Salina formation, being to a great degree composed of weak rocks, is probably excavated and buried more deeply than the others. The Clyde, the present outlet of the Finger lakes, runs through it lengthwise (W.–E.); for several miles west of Lyons its valley is deserted by its wandering occupant; the banks are there 30 feet high exclusive of drumlins, and rock is not exposed.

Distinct evidence in regard to the depth of the drift-covering is less easily had in this formation than elsewhere. The

* For a sketch map of the Lake region, see this Journal, October, 1892.

drumlins are numerous, and intercept the drainage to such an extent that the low grounds between them are largely filled with alluvium, and often swampy. Hall, however, mentions 16 localities where the rock is exposed. A comparatively continuous series of exposures is seen along the line of contact with the next following rock.

The Corniferous limestone makes itself seen in many places along the south side of the Auburn branch of the New York Central railroad. It comes close to the surface at many quarries; and its low escarpment, resembling an old stone wall, west of Geneva, has forced the railway to diverge four miles to the north. Upon this escarpment, a mile south of the New York Central, runs the new line of the Lehigh Valley road, cutting through some low anticlinals of rock resembling those mentioned in the case of the Niagara limestone, and with a similar (N.–S.) axis. Both roads run for some miles west of Geneva over broad levels of Corniferous limestone covered with a little soil and occasionally swampy. The Lehigh road has found it impossible to plant posts in the usual way, and stone-laden cribs are used to support the fences.

With the Corniferous begins the series of exposures belonging to the lake-region proper. In this region no other escarpment of equal development exists. Locally, however, we may name that due to the Tully limestone, a sheet of rock a dozen feet or more in thickness, surmounting the Hamilton group. At its outcrop in the rising land between Seneca and Cayuga Lakes, just north of Ovid, there is a shoulder or upward jog in the landscape, quite well seen at a distance of eight miles. The "basal limestone" (J. M. Clarke), which forms the lowest layer of the Hamilton shale, parting it from the Marcellus, is the cause of the bluff northerly termination of a certain detached hill, four miles south of the outlet of Seneca Lake; the soil is very thin over a large tract, and the coral reef is bare in spots. Many hundreds of little ravines, entering the Finger Lakes from the sides, and cutting through the Devonian series, have made the region classic ground for the collector of fossils. The drift-coating, as shown in these cuts, is usually thin (1–5 feet) at least within a mile or two of the lakes. In many places, however, the delta-terraces are prominent, and where cut through by the railways might mislead the observer's estimate. It is fair to presume that these accumulations of drift were not, for the most part, taken from the general surface, but from those surfaces which have now been converted into ravines and gullies. The general sweep and slope of the country is not towards the ravines, as a rule; the upland contour is broken abruptly by the line of the gorge, and there plunges at an angle of from 20° to 90°. Hence, little general loss of drift has probably taken place through stream-action.

The *general topography* of the district—its hills, valleys, and slopes—furnish important aids to determining the amount of drift. On the whole, these features are formed of rock, veiled under a very few feet of drift. Although the country along the lower (northern) reaches of the lakes is in general level, yet it is not without marked features. The hill of coral limestone just described is one of several, similarly elongated parallel to the lake-axes, and formed of shale. They are described in this Journal for October, 1892. Other hills and ridges may be added to their number. Farther south, towards the neighborhood of the moraine of the second Glacial period, as defined by Professor Chamberlin, the country rises very considerably, forming for the most part a series of broad backs, plateau-like, intersected at short intervals by straight, trough-like valleys, running nearly N.–S. Most of these valleys contain lakes. The moraine is very weak on the high lands, over which it lies in loops bending northward. It crosses the valleys a short distance south of the present lakes, and has evidently determined their position. In the valleys, the accumulations are vast, with extensive overwash deposits southwards towards the Susquehanna, and northwards towards the lakes (?) Over a great part of the rolling uplands it is safe to say that the rock lies within from one to ten feet of the surface. They are in places characterized by rock-flats covered with thin soil; in other parts they undulate in broad clumsy lines, forming certain high hills and a few transverse or E.–W. valleys with rock sides. A good example of the latter is found at Dundee, which lies about ten miles north of a locality named by Chamberlin as belonging to the moraine. The existence of such a valley at such a point is not suggestive of a heavily drift-blocked country. Several other valleys, in similar situations north of the moraine, remain as the last survivals of a topography which is clearly *not post-glacial;* they appear in harmony with the valley system of the Allegheny plateau of western Pennsylvania.

These remarks, however, must be understood as limited to the high lands lying southward; whose topography in fact much resembles that south of the moraine. The lower lands, including the northerly reaches and the troughs of the lakes, produce the impression of a typically glaciated country, with few prominent features. The forms are smooth and flattened, even when demonstrably due to rock-structure. Any long stretch of horizon tends to resemble a line drawn with a ruler. Looking east or west, the sky-line is nearly level; looking north or south we have broad planes inclining to the lakeside.

On the lower levels—say up to 900 feet above tide—a good deal of the land between the lakes is provided with drumlins of moderate size, and of a different aspect from the bolder

and larger forms of the parts nearer Lake Ontario. The material of these small drumlins, if spread over their own neighborhood, would not exceed 10 or 20 feet in thickness.

Kames and osars have been observed in three counties, but not with sufficient system to enable an estimate to be offered. It is not believed that the material they contain would add very greatly to the total.

The deepest parts of the lakes may be assumed, with probability, to be nearly free from drift. On the south they are prolonged in alluvial plains, reaching several miles, which may not be all Post-glacial. The northern ends of several lakes also appear to be choked with Glacial deposits. At Geneva several wells have been sunk at the water's edge, passing through gravel, sand, clay, and till, with many large bowlders, and striking bed-rock at 205, and 240 (?) feet. Adjacent drumlins rise to the height of 90 feet. A mile from the lake, at an elevation of 100 feet, the drift is 60 feet thick; half a mile further, on higher ground, shale crops out in several spots. This drift-mass extends six or eight miles to the southward, occupying the width of a mile on the west bank of the lake, and very probably shoaling a corresponding portion of the lake. On the whole, it may be estimated that $\frac{2}{5}$ of the surface of land lying between the Finger Lakes and extending to (but not including) the terminal moraine, is covered with drift, averaging from 1 to 5 feet in thickness. Another $\frac{2}{5}$ may average from 5 to 30 feet. The remainder may be included, for the most part, between 30 and 100.

In close connection with the above study, a question of great interest awaits solution—that of the origin of the trough-like lake-basins. The reader will not fail to recall the diversity of opinion, which has been recently developed by the discussions upon the origin of mountain lakes, in the pages of "Nature" for 1893. It is not my present purpose to enter into this discussion. Certain facts, however, in part new, may well be mentioned here, as deserving to be weighed before we take sides. In part, these favor the theory of deepening by Glacial erosion; in part, that of tilting or differential uplifts, whereby valleys that once ran continuously to the sea have been bent so as to hold water like a spoon. For the sake of simplicity, let us confine the presentation to Seneca Lake, which will serve as a type. Situated in the axis of the system known as the Finger Lakes, this valley has been cut down to a depth considerably greater than either of its neighbors; in addition to which, it is the one about whose rock-contours we have most definite information. We will consider it as incidental to a valley, 58 miles long, running from the flat land at Geneva south to a junction with the Chemung Valley at Elmira; of

which valley the lake occupies the northern 36 miles, and the terminal moraine with its dependent deposits occupies the remaining 22 miles.

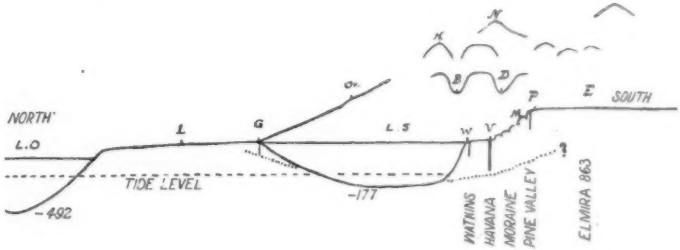


FIG. 1. Section from Lake Ontario southward through Seneca Lake to Elmira. LO, Lake Ontario, bottom 492 below tide level; L, Lyons, 407 above tide level; G, Geneva; O, Ovid, 1061; LS, Seneca Lake, surface 441, bottom —177; H, Hector (summit) 1805; B, Burdette; N, Newfield, 2095; D, Odessa; W, Watkins; V, Havana; M, Moraine; P, Pine Valley; E, Elmira, 863.

The greatest depth of the valley is at and to the south of the middle of the lake, where the bottom lies 150–176 feet below tide. At the north end, the lake comes to an abrupt end, choked with drift and alluvium; the valley also disappears to the eye and is not traceable farther north. The apparent depth of the lake at this part is 40 feet; its true depth is probably not much in excess of 200 feet, as may be inferred from the section (fig. 2) in which the borings are shown to represent two localities, distant 1700 feet in a line at right angles with the channel, and near its probable axis. The lake-level being 441 A. T., the buried channel would be at 241 A. T.

FIG. 2. Section across Seneca Lake at Geneva, from west to east, showing probable depth of buried channel. R, Reservoir; C, Castle Creek; G, Geneva Nat. Gas Spring Co.; Ch, Chase's well; N, Nester's well; M, outcropping of Marcellus shale.

For the part of the valley lying south of the lake the following data have recently been obtained. At the mouth of the "inlet" at Watkins, near the middle of the valley, a well has been driven "by blows from a sledge" 224½ feet in the alluvium. Four miles south, at Havana, a well was sunk at Cook Academy, near the middle of the valley, which passed through 435 feet of sand without reaching rock. Six miles farther south (one mile beyond Millport) a well was sunk

by Mr. U. Hall to the depth of 186 (?) feet in sand, without touching rock; the site of the well was near the brook, which has cut its gorge to the depth of 100 feet (estimated) below the level of the drift at that point, which indicates 300 ± feet of drift in all. At Elmira the valley is two miles and a half wide; the Erie road runs near the middle; borings have been made at the Table factory, just west of the road, giving *less* than 200 feet of gravel, and at the Rolling mills, just east of the road, striking rock at less than 60 and 120 feet; while at the Blast furnace, in the same region, I am informed by a former official that their well could not have gone more than 100 feet in depth before striking rock. These data are all that seem at present available. We may therefore assume that the drift deposits of the valley equal or exceed 300 feet in thickness until we approach Elmira, where they probably become less than 200, perhaps less than 100 feet thick. This places the southern end of the valley at 680–780 feet above tide = 850–950 feet (in round numbers) above the deep parts of the lake-floor; the northern end of the valley being about 400 feet above the lake-floor.

In the valley of the Susquehanna, between Wilkesbarre and Bloomsburg, a similar state of inversion has been shown to exist (2d Geol. Rep. of Pennsylvania, G 7). Wilkesbarre is 124 miles down-stream from Elmira; Bloomsburg is 40 miles further. At Wilkesbarre the existing river deposits have been pierced by boring to the depth of 180 and 185 feet before striking rock, showing the existence of a buried bed at 340 feet above tide; while at Bloomsburg the rock-bed is exposed in the stream at a height of 450 feet above tide, giving a tilt of 110 feet in a direction contrary to the present course of the river.

The hypothesis of crust-bending is obviously available to explain such differences of level as the above. It seems to me however, that the arguments for the other side are of great importance. There are three principal ones.

1. The magnitude of the valleys of Seneca and Cayuga Lakes demands an explanation which has not yet been offered. The Seneca valley at its wider and deeper parts greatly exceeds in dimensions that of the Ohio below Pittsburg; this would not be inconceivable, if we supposed both the Susquehanna and the Chemung to have flowed north past Elmira and Geneva Ontario-wards; but it is less easy to account for a second valley, that of Cayuga Lake, parallel with it at twenty miles' distance, and nearly as large as the first. Further, the character of the valleys of these lakes changes in going south to the moraines; they become narrower, and assume the aspect of cols. See fig. 3.

2. A much more important group of objections exists, which may be summed up under the title of Incompatibility of Levels.

*a.* To the east and west of the Seneca valley, at a distance of 6–12 miles, there run two upland valleys; on the east, that of Cayuta Creek, 26 miles long and half a mile wide; to the west, that of Pine Creek, about half that length. They begin opposite Watkins and run southward. In this situation it is hardly conceivable that a general flexure, capable of affecting the beds both of Seneca and Cayuga Lakes, should fail to affect similarly the valley of these creeks; especially as Cayuta valley lies between the south extensions of Cayuga and Seneca valleys. But in point of fact, this is what has occurred :—the valley of Seneca falls *northward*, its probable bed descending nearly 900 feet in 30 miles (Elmira 700 ± A. T., lake-bottom 176 below tide]. The valley of Cayuta Creek falls *southward*, descending probably 300 feet in 26 miles (and doubtless considerably more, if its rock-bed were uncovered at its lower part). Pine Creek similarly falls 337 feet *southward* in 13 miles from Beaver Dam (1279) to Corning (942). It is of course quite possible that streams should interlock in this way over a divide, flowing in opposite directions for a time. But it is unlikely that a large river (by supposition, the upper Susquehanna) should have run from Elmira north with a descent of 30 feet to the mile for 30 miles. If such were the state of things, a deep narrow gorge with vertical sides would have been produced, extending back at a relatively rapid rate far down into Pennsylvania. The actual outlines of the section of the lake (fig. 3) are absolutely contradictory of this view.

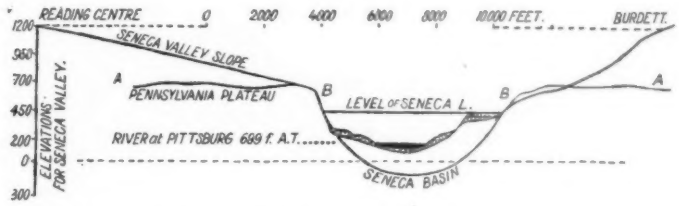


FIG. 3. Combined sections of Seneca Lake and the Ohio River, on the same scale (vertical 4 times the horizontal). The lake is taken near the southern end, on line III of Cornell University map; from Reading Centre east to hill at Burdett. The river (ABBA) is an average section within 12 miles below Pittsburg obligingly furnished by Prof. F. W. Very of Allegheny, Pa. Width of lake 6250 feet; width between the Ohio bluffs (B–B) 7000 feet; width of lake-valley between high points 22,000 feet. Depth of water in lake 540 feet. (The greatest depth is 2 miles north of section = 618 feet.) Depth of Seneca valley, from level of bluffs 800 feet; from level of plateau (Reading Centre), 1400 + feet. Depth of Ohio valley, from plateau at bluffs (B–B), near 500 feet.

*2b.* The incompatibility between the Seneca valley and those of the high land appears further in this: that if they had coexisted, the deeper must have "robbed" the less deep.

The smaller upland creeks above named, lying nearly 1000 feet higher than the Seneca bottom, and distant only 4 or 5 miles, without obstructing elevations of ground, must inevitably have become its tributaries. But not the first step seems to have been taken towards this end. The upland systems were uninfluenced, during their formation, by such an attraction; hence we may infer its non-existence.

3. Probably the most important argument in this direction is drawn from the *absence of side valleys* along Seneca and Cayuga Lakes. In this respect, the lake-scenery presents a remarkable contrast to that of the valleys lying beyond the line of moraine, which are entirely typical in this respect. The contrast is observed immediately on crossing the moraine, e. g. to the south of Havana; still better, along Cayuta Creek. While the latter valleys are notched down to the flood-plain level, every mile or two, the lake-side for stretches of 10–15 miles seems like an artificially smoothed garden-slope.

Professor Chamberlin noticing this, suggests as a probable view, that at least one-half of the depth of the old side-valleys has been lost through the shearing action of the glacier upon the projecting bluffs. The remainder of the effect is due to filling with drift. This is exactly in the direction of the present line of thought. But it seems necessary, in view of certain conditions, to carry this observer's views to a somewhat more radical conclusion. These conditions are the following:

The upper twenty miles of Seneca Lake is bordered by a continuous line of cliff, varying from 20 to 100 feet in height, but presenting only very gradual changes in level. As the coast forms almost a straight line, the inference is clear that no deep incisions exist at that level, or from 500 to 600 feet above the lake-bottom—practically, about half-way up the valley-side, where the side-notches would have made the deepest incisions. These remarks are intended to apply only to such small, but deeply cut notches as would correspond to streams of half-a-dozen miles in length: such, for instance, as may be seen by following the valley ten miles southwards from Watkins. Larger valleys, joining the lake at near the present water-line, may be instanced; Seneca Lake has one such at Dresden, which seems to have formed the original outlet of Keuka (Crooked) Lake; the Post-glacial gorge follows the same route. Cayuga Lake has the valley of Salmon Creek, opening at Ludlowville, near Ithaca, and running some 16 miles midway between Cayuga and Owasco Lakes. The bottoms of these valleys contain a very heavy deposit of drift, but not enough to prevent their forming impressive features of the landscape. Other than these, no important valleys enter the two lakes. The fluctuations in the height of the lake-cliffs suggest that

we may yet trace the residue of the old side-notches in degraded forms. The same is suggested in places by curves in the higher landscape.

As representing several aspects of this discussion, let us consider the case of the valley at Dundee, which lies ten miles north of Watkins. Its banks are composed of Chemung sandstone, thinly coated with drift; they rise several hundred feet above the little valley at a moderate angle. The stream runs in a tolerably direct course towards the lake for about five miles, with a moderate fall of 4–20 feet per mile. Passing the village of Dundee—where it runs over rock for a mile—the stream cuts under the viaduct of the Fall Brook railroad, and at once begins a plunge of 500 feet, which it accomplishes in less than two miles by a line of post glacial gorges. If it could descend to the bed of the lake, the remaining 600 feet of fall would be accomplished in one mile. Such a case appears to show (1) the loss, through lateral shearing, of the Dundee valley, beginning at the point where its plunge commences. The modern landscape suggests the same. (2) The deepening of the main channel of Seneca, to an extent sufficient to enable us to bring it into correlation with such tributaries as this upland stream. Obviously, this implies a large figure—several hundreds of feet both laterally and horizontally.

In conclusion, it is worth notice that Dundee valley, and other valleys at corresponding heights across Seneca Lake, on the east side, agree very fairly in elevation with the system of petty valleys antedating Glacial time which empty into the Chemung near Elmira. The trough of Seneca Lake (with that of Cayuga) stands an exception to the harmony, and its excessive depth is from several points of view irreconcilable with the hypothesis of pure river-erosion, with or without crust-bending.

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## Art. XV. — *On the Basalts of Kula;* by Henry S. Washington, Ph.D.

The following pages are a resumé of an inaugural dissertation presented by the writer last July at the University of Leipzig for the degree of Ph.D. The original dissertation being of too great a length and containing too much matter (historical and topographical) foreign to the scope of the Journal this paper was prepared embodying the chief and most interesting petrographical facts and conclusions. This being the case, the reader will pardon conciseness and the omission of much detail, and for further information may be referred to the original which is to appear shortly in New York as a separate pamphlet.

The rocks treated of were collected by the writer in the spring of 1892 near Kula, a small town of Asia Minor, lying about 125$^{km}$ E. by N. of Smyrna in a part of what formed the ancient country of Lydia. This special district was called by the Greeks Katakekaumenē—the Burnt Country. It is a tract, about 18 miles long by 8 wide, on the left bank of the Hermos River (now Gediz Chaï); three basins of tertiary limestone, separated from each other and bounded to the south by ridges of mica (and hornblende) schist, while to the north are limestone hills. These basins, and the schistose ridges, are covered with well shaped volcanic cones and large lava streams and fields, which belong to three distinct periods of activity. The earliest is represented by large basaltic sheets, much denuded in places, lying rather outside the basins proper, and not treated of here. The second period is represented by over thirty cones, mostly on the schistose ridges, the forms denuded and somewhat rounded and lowered, and covered with vegetation, as are also their lava streams. To the third period belong three large volcanic cones—one in each basin—in an exceedingly fresh and unaltered state, their slopes of scoriæ bare of vegetation, and the lava streams as black, fresh, and rugged as those of the modern outflows of Vesuvius or Etna.

The large cone of the Kula Basin (the easternmost) is known as *Kula Devlit*, or Kula Inkstand, the black lava streams looking like ink running from an overturned inkstand. It has a height above sea level of 885 meters, above its base of 165 meters, and its outer sides slope at an angle of 30° 30′. It is a typical cinder cone, and shows two craters, one smaller in the southwest corner of the larger, and both extremely well preserved. No emanations or other signs of present volcanic activity are to be noticed. It has several lava streams, the

largest running north to the Hermos River, a distance of about 10$^{km}$. A few smaller third period cones are to be found in the basin, and the Turks call the whole field of cones and black lava *Janyk Tash*, Burnt Rock.

As to the date of their eruption we know nothing, historically or traditionally; but as is evident from their fresh and unaltered state, it must have been within historical, or very recent quaternary, times. For the ancient description of the district the reader is referred to Strabo,* and of the very scanty modern notices the best are those of Hamilton,† Hamilton and Strickland,‡ and Tchihatcheff.§

The lavas of both the second and third period outflows are to be classed as hornblende-plagioclase basalts, distinguished by the constant presence and great relative quantity of the hornblende, its peculiar magmatic alteration, the small quantity of both plagioclase and olivine, and the large amount of glass basis. They form a distinct (and in some points new) type of the group, so much so as to be worthy of a distinctive name, that selected being *Kulaite*, the definition and characteristics of which being given later. They are all very fine grained compact rocks, gray or iron-black in color, and of low specific gravity. Hornblende, presenting the usual features of basaltic hornblende, olivine and augite, are visible megascopically, as porphyritical crystals. Occasional enclosed fragments of quartz, clear and with the usual fringe of augite needles, are to be found, some reaching a diameter of several centimeters. These are most certainly foreign enclosures.‖ The lava—especially of the third period—is vesicular and in some of the outflows shows a decided columnar structure, in one place on the Hermos River the columns attaining a length of six meters.

An interesting mineralogical feature of two of the Kula Devlit streams is the presence of leucite in small characteristic crystals. This is only the second time that it has been observed in Asia Minor, Lacroix¶ having found it in rocks from Trebizonde. These leucitic basalts seems to have their continuation in Persia. It is also to be noted that this is the first recorded case of its occurrence in hornblende basalts; nepheline, which is a very frequent constituent, not having been here observed.

* Geography, xiii, 411.

† Researches in Asia Minor, etc. London, 1842, i, 136–140, ii, 130–150.

‡ Trans. Geol. Soc., 2d Ser., vi. 81.

§ Asie Mineure, Pt. IV, Geologie. Paris, 1867, I, 7.

‖ Throughout the paper the word "enclosure" is used for such foreign masses accidentally enclosed in the lava stream, while "inclusion" is reserved for crystals, etc., structurally included in the other component minerals.

¶ Bull. Soc. Geol. de France, xix, 1891, 732.

The component minerals may be now described and we begin with

*Feldspar.*—This is constantly a plagioclase, and is sparingly present. In the second period Kulaites it is found in leptomorphic grains forming, with the glass basis, the groundmass of the rock. In the latest flows, on the contrary, it is constantly in the form of lath shaped microlites in the glass basis, generally very minute, but in some cases attaining a length of $0{\cdot}1^{mm}$. They show fluctuation structure and seem to have been among the last products of crystallization, being very sparingly present in the tachylitic forms. This plagioclase, but very rarely porphyritic, is shown by optical examination to be bytownite.

*Augite.*—The largest, megascopically visible crystals are light greenish yellow, and generally fragmentary. The greater part though is in well formed crystals, from $0{\cdot}1$–$0{\cdot}4^{mm}$ long, generally elongated parallel to $c$, and showing the usual planes. They are either colorless or of a very pale fawn gray, sometimes with a core of greenish gray. The extinction is normal, though in one case as high as 43°. The prismatic cleavage is not well developed. As inclusions were seen glass and groundmass, rarely hornblende, and still more rarely magnetite, the latter in a few cases arranged in small grains parallel and close to the plane $s(\bar{1}1\frac{1}{2})$. Twins are not common. The well known "hourglass" structure was well developed and some interesting modifications were noticed. A zonal structure is very frequent. Augite is also present as a microlitic constituent of the groundmass, scattered thickly through the glass basis, and showing fluctuation structure.

*Hornblende.*—This, of all the constituent minerals, is the most constant and characteristic, and offers the most points of interest. It is present in relatively large quantity in all the lavas examined, in the leucitic, as well as in the non-leucitic, in the pure tachylytes and in the basalts of a normal structure—it is in fact the stamp and seal of the Kula basalts. Megascopically it is more frequent and prominent than either the augite or olivine, the crystals sometimes reaching a length of $8^{mm}$, showing all the usual characters of basaltic hornblende—dark brown color, rounded edges and pitted surfaces.

Under the microscope it is seen that it is always porphyritic, never forming part of the groundmass. It is well formed, in short stout crystals, showing the usual planes, and with the cleavage well marked. The color is usually yellowish brown, but occasionally, and this as a rule in the more glassy specimens, it is greenish yellow. Pleochroism strong; $(c)$ = dark yellowish brown; $(b)$ = yellowish brown, $(a)$ very pale gray, $(c) > (b) > (a)$. The angle of extinction varies from 4° to 14° 30′,

in one case being 23°. Zonal arrangement of the color is very common in the larger brown crystals, a dark core being surrounded by a light zone, or rarely several zones alternately light and dark. The dark core occasionally shows a corroded outline. Inclusions are not common, being chiefly glass, which are frequently arranged parallel to the outer planes of the crystal, or make up a central core of shape similar to that of the host. Augite is sometimes seen.

The alterations undergone by the hornblende are of great interest and will be described at some length. Of cases of mechanical distortion or simple corrosion nothing need here be said. The chemical alterations—to be ascribed to magmatic action—fall under three heads. The first, observed almost exclusively in specimens of scoriæ, consists of a simple darkening and reddening of the original crystal, without any change of form. It need not detain us here. The other two seem to be more or less connected with one another, and may be separate stages of one process, or two similar processes. The first consists of the replacement of the hornblende substance by a reddish brown mineral, in small elongated crystals, accompanied by grains of colorless augite and black "opacite;" in the other the outer part, or it may be the whole, of the hornblende crystal is changed into a mass of augite and opacite grains. This last is of very frequent occurrence in all eruptive rocks, though more common in the basic ones, and affects the biotite as well as the hornblende. The nature of the black grains of the so-called "augite-opacite aggregate" is not definitely known, but, with most observers, the writer is inclined to think them magnetite. Though very frequently the original form of the crystal is scarcely changed, yet in some specimens from a second period stream, obtained from a well-digging, at a depth of about 35$^{m}$, the hornblende "pseudomorphs," as they have been called, have lost their original shape, and are reduced to spheroidal or ovoidal masses, or as one writer puts it, looks "as if they had melted and run"—a natural consequence of the action of a moving lava stream on the granular, and probably not very coherent, mass of alteration products.

The alteration to "brown mineral aggregate," on the contrary, is of quite rare occurrence, only thirteen references to it having been found in the range of petrographical literature. Its geographical range is large, though, as first noticed by Zirkel,* in 1870, in some Eibel basalts, it has since been found (always in hornblende basalts) in Saxony, the Rhone, Palma, Syria, Madagascar, Kilimandjaro, and Cabo de Gata in Spain. It has never been observed in biotite.

* Basaltgesteine, p. 26. Cf. Rosenbusch Mik. Phys., 3$^{te}$ Aufl., i, 560.

The characteristic feature of this alteration is a reddish brown mineral in small "club-shaped" crystals, not scattered pell-mell through the accompanying augite and opacite grains, but forming a sort of network, the crystals lying at angles of about 60° with each other, and two sets also at the same angle with the prismatic edges of the hornblende crystal. At the end of the hornblende crystal the small brown bodies are generally arranged in slightly diverging fan-shaped tufts, spreading inwards. Definite crystallographic planes cannot be made out, though the blunt pointing of the terminations indicates a dome. The pleochroism is very strong, vibrations parallel to the long axis olive green (the least absorption), and at right angles to this respectively light brown, and very dark red brown (the greatest absorption). The extinction noted was, in every case, parallel to the long axis—in this point alone my observations differing from those previously made, other writers noting extinction angles of from "parallel or little inclined* (Palma) to maxima of 20°† (Kilimandjaro) and 25°‡ (Syria)." It must be remarked that in the Kulaites the opportunities for observation seem to have been far superior to any others, the crystals being of fair size, quite distinct from each other, and, the slides being well made, of fairly light color. Filling the interstices between the brown crystals are grains of colorless augite and opacite.

This form of alteration, like the other, begins at the surface of the hornblende, or along cracks, and thence spreads inwards. It seems to show a preference for the dark variety of brown hornblende (the green never being so altered), and frequently the dark core is altered while the outer light zone is unchanged,—apparently having been deposited after alteration took place in the core. A striking fact in connection with this, as with the preceding, form of alteration is the perfect manner in which the hornblende crystal has, as a rule, preserved its form, while undergoing such a profound change of substance. This will be referred to later.

It has already been said that these two forms of alteration seem to be separate stages of one general process. It is certainly true that the simple augite opacitic type follows on the other in many cases, and numerous examples were noted where are to be seen a core of unchanged hornblende, then a zone of the "brown mineral aggregate," and last on the outside a simple augite-opacite border. Or again, the central core of hornblende has entirely disappeared, giving place to the

* van Werveke, Neues Jahrb., 1879, 825.
† Hyland. Min. pet. Mitth., x, 1888, 238.
‡ Doss. Min. pet. Mitth., vii, 1886, 515.

"brown mineral aggregate" with a surrounding augite-opacite zone.

Two questions present themselves for solution, and answers to them are now attempted. What is this peculiar "brown mineral?" What is the cause of the alterations, and of the difference in the two "stages?"

*Brown mineral.*—In regard to the first it may be premised that the nature of the mineral is so far not certain. Nearly all observers call it hornblende, with more or less confidence, basing this conclusion chiefly on the usually observed slightly oblique extinction. As has been seen, in the Kula basalts the extinction was always parallel, and, however the discordant results of other observers may be explained (as they can be to some extent), the writer gives it as his opinion that the mineral in question is hypersthene, basing this conclusion on the following facts:

*a.* The unanimous results of all experiments made show that melted hornblende on cooling crystallizes invariably as augite.* "It is hard to see how this tendency can be overcome."

*b.* The color and pleochroism of the brown crystals agrees perfectly with that of hypersthene, calling the axis of greatest length $\dot{c}$, as is also usually the case with hypersthene.

*c.* The constant parallel extinction observed by me indicates an orthorhombic mineral and points to hypersthene.

*d.* On the theory that the crystals are hornblende the arrangement at angles of 60° with one another is very difficult of explanation. In hypersthene however we find that the dome 101 is a twinning plane, giving an angle between the two $\dot{c}$ axes of 60° 58′, and such twinned needles of hypersthene have been observed† in andesite from Bukowina. The case of similarly twinned rutile needles (sagenite) may be recalled.

*e.* Augite and hornblende tend to crystallize, when together, in parallel position, and when we use the pleochroism as a means of orientation we find that if the crystals are hypersthene their $a(100)$ corresponds with that of the hornblende when the $\dot{c}$ axes are parallel.

*f.* The alteration of hornblende to hypersthene (along with feldspar, augite and magnetite) has been several times observed, as in andesites from Mexico, Arequipa in Peru, and Cabo de Gata, the rhombic pyroxene in the latter case being called bronzite.

It must be added that the unsatisfactory and indeterminative result of a chemical analysis of a dark spot containing

* Cf Becker, Zeits. d. d. geol. Ges., xxxvii, 1885, p. 10.
† Becke, Min. pet. Mitth., vii, 93.

much brown mineral was, if anything, rather against the hypersthene theory.

*Causes of alteration.*—We now come to the question of the causes of the two kinds of alteration. The limits of the present article will not allow us to go into detail on this subject but some space may be devoted to the phenomena to be explained and a sketch of the possible explanation proposed. The facts are as follows: The brown hornblende is more subject to both forms of alteration than the green, and it is often, but not necessarily, changed first to "brown aggregate," and this to the simpler augite-opacite aggregate. The changes begin at the surface, or along cracks, of the hornblende, and thence work inwards, and when along cracks no contact with the molten magma exists. Both alterations occur with necessarily no marked change of form in the original crystal. A layer of fresh hornblende can be deposited on substance altered to brown aggregate, but has not been observed on that otherwise altered. Both alterations are more common in the basic volcanic rocks, and are the more marked the less glassy the groundmass. The "brown aggregate" alteration seems to have taken place at a greater depth than the other.

A number of explanations have been given varying from the vague general idea of "corrosive action of the molten magma" to the statement that the hornblende crystal has been melted or dissolved, and the new alteration product (?) deposited in its place. Lack of space forbids an examination of them here, but it may be remarked that the perfect preservation of the crystalline form precludes, in the writer's mind, any possibility of fusion or solution of the hornblende in a molten moving magma. To sum up it may be stated in brief that all the theories proposed are too vague or too improbable to be admitted as true.

The writer's idea in regard to the formation of the brown aggregate is that occluded hydrogen (produced by dissociation of the water almost always present in lavas) acts as a powerful reducing agent, changing the $Fe_2O_3$ of the original brown hornblende to FeO, and under certain conditions of high temperature and pressure (with probably others) giving rise to a mixture of the ferrous magnesian silicate, hypersthene, along with augite and magnetite. This process, it will be observed, requires no fusion or solution of the hornblende.

A chief factor in the formation of the augite-opacite aggregate the writer looks for in a simple molecular change (similar to that of monoclinic to rhombic sulphur, etc.) under certain conditions, among which are probably the chemical constitution of the magma and a slow rate of cooling, with certainly a high temperature.

These theories are, it is admitted, but probable, not certain, and for the further discussion of the subject the reader must be referred to the original dissertation.

*Other minerals.*—The other mineral constituents need not detain us long. The olivine is very sparingly present, and offers no special features of interest. Two cases of inclusions of black trichites, in groups, were noticed—a rare occurrence in basaltic olivine. The magnetite of the groundmass is always in very small grains, rarely reaching a diameter of 0·1$^{mm}$. The most interesting feature of its occurrence is that in the least glassy Kulaites the magnetite grains are very abundant and the glass basis perfectly colorless, while as the rock becomes more glassy the quantity of magnetite decreases and the glass assumes a brown hue, till finally in the pure tachylytes no magnetite is to be seen and the glass is of a clear dark chocolate brown color. This seems to show that in these rocks the magnetite is among, if not quite, the last of the minerals to crystallize out. Its rarity as an inclusion points the same way. It may be noted that Judd* observed exactly the opposite state of affairs in the Tertiary gabbros and basalts of western Scotland. The leucite offers no special features of interest. That apatite is present is shown by the presence of $P_2O_5$ in the analyses, but crystals of it were not certainly seen, except a few large ones, which are certainly derived from enclosures of foreign rock.

*General description of the rocks.*—All the basaltic rocks of the Kula district are very similar to one another in composition —chemical and mineralogical,—as well as in the habit of their mineral components, and form a good, though small, example of a so-called "petrographical province." Structurally they may be divided into normal, hyalopilitic, semi-vitreous, and tachylytic basalts, these subdivisions shading off into one another.

To the first of these belong the specimens of the second period streams—light gray, rough fine grained rocks, of average sp. gr. 2·756, with porphyritic augite and olivine. Under the microscope they show a groundmass of glass and leptomorphic plagioclase grains containing many microlites and magnetite, with small porphyritical augite and olivine crystals, and numerous hornblende crystals, which have all, without exception, undergone alteration, generally completely to a mass of augite and opacite. Rounded forms are quite common.

The third period basalts are more glassy, and a hyalopilitic structure, of quite typical development, is common, the microlites being plagioclase laths, augite needles, and magnetite

*Q. J. Geol. Soc., 1886, 79.

grains, with some trichites. Phenocrysts, of hornblende, augite and olivine, are abundant, the first being generally altered to the "brown aggregate" stage. Those of a "semi-vitreous" structure have a pitchy luster. In them the groundmass shows a largely preponderating quantity of clear cinnamon brown glass, and they have lost, with reduced number of microlites, the hyalopilitic structure of the preceding. Some greenish hornblende appears, but this, as well as the brown, is commonly free from alteration, and the alteration when present is always to "brown aggregate." The tachylytes are very compact, jet black, with a vitreous luster, many specimens looking like anthracite. They consist almost wholly of a clear dark chocolate brown glass, often streaked. Very few microlites and no magnetite are present. Phenocrysts are represented by large augites and hornblende crystals, the latter frequently showing a zonal structure, but always fresh and unaltered, both brown and green, the latter having become more frequent. Olivine is very rare. The average sp. gr. of the hyalopilitic type was found to be 2·655, of the semi-vitreous 2·704, and of the tachylytes 2·721. Two lava streams of Kula Devlit are leucitic. They are both hyalopilitic in structure, and, apart from the presence of leucite in not very abundant, small crystals, are not markedly different from the non-leucitic type. Their sp. gr. is 2·719.

The following may be selected as typical analyses out of those made for me by Dr. A. Röhrig of Leipzig.

| | A. | B. | C. |
|---|---|---|---|
| $H_2O$ (Ign.) | 0·02 | 0·46 | 0·04 |
| $SiO_2$ | 48·24 | 47·50 | 47·74 |
| $Al_2O_3$ | 20·64 | 19·32 | 20·95 |
| $Fe_2O_3$ | 4·63 | 4·75 | 3·29 |
| FeO | 5·55 | 5·20 | 6·32 |
| CaO | 7·94 | 8·37 | 7·56 |
| MgO | 5·02 | 4·36 | 5·16 |
| $Na_2O$ | 5·08 | 7·63 | 7·12 |
| $K_2O$ | 1·88 | 2·31 | 1·21 |
| $P_2O_5$ | 0·97 | 0·21 | 0·13 |
| | 99·97 | 100·11 | 99·52 |

A = Second period Kulaite from well-digging in Kula. Sp. gr. = 2·733.
B = Third period. Early stream of Kula Devlit. Sp. gr. = 2·704.
C = Third period. North stream of Kula Devlit. Leucitic. Sp. gr. = 2·736.

The mutual similarity is most marked, but nothing special need here be said, except to call attention to the small quantity of $K_2O$ in the leucitic specimen, analysis C.

A few words on the bestowal of a name on these rocks. While deprecating the too free use of new names, yet in this case the writer deems it justifiable. In all the Kula basalts the hornblende plays the leading rôle, surpassing in constancy, invariability, and quantity the augite, olivine or feldspar. It is not of secondary importance, as in most hornblende basalts, but of the first importance among all the mineral constituents. The name chosen is Kulaite, and by this we may understand a sub-group of the basalts which is characterized by the invariable presence of hornblende as an essential constituent, which also, both in quantity and petrographical importance, surpasses the augite: in other words to a large extent replaces the latter. We can call such a plagioclase-basalt kulaite, having the further subdivisions of leucite-kulaite (as just seen), and nepheline-kulaite.

In addition to the volcanic rocks just described a number of metamorphic schists, serpentine, diorite from a dyke in the schist, and foreign rock enclosed in the basalt were examined. It may be added that the writer hopes to revisit the region the coming spring, when a longer stay will be made, and data and specimens from the whole of the Katakekaumenē will be collected. The writer desires to return his warmest thanks to Prof. Dr. Zirkel of Leipzig for his very kind advice and assistance and to Prof. E. S. Dana for his kind advice.

Navesink, N. J, Nov. 11, 1893.

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## Art. XVI.—*The Fishing Banks between Cape Cod and Newfoundland;* by Warren Upham.*

Along a distance of about a thousand miles east-northeastward from Cape Cod the submarine border of the North American continent presents very remarkable irregularities of contour. The sea bed there in its descent from the present coast lines to the abyssal depths of the North Atlantic Ocean differs entirely from the smooth and gently inclined plane of the submerged continental slope along its next thousand miles south to the Strait of Florida and the Bahama Islands. Instead we find by soundings from Cape Cod to the Grand Bank of Newfoundland that this section of our coast has a profusion of submerged hills and broad plateaus, elevated from 100 to 1000 feet above the intervening valleys and adjacent low portions of the sea bed, from which they rise nearly to the sea

* From the Proceedings of the Boston Society of Natural History, vol. xxvi, pp. 42–48, for March 15, 1893.

level but only in a single instance reach above it, forming Sable Island. These plateaus, covered by water ranging mostly from 10 to 50 fathoms in depth, sustain luxuriant submarine vegetation, abundant molluscan life, and vast schools of cod, haddock, mackerel, halibut, and other food fishes, which almost from the time of first discovery and exploration of this coast have caused its submerged plateaus to be the site of important fisheries and thence to be known as Fishing Banks.

In their order from southwest to northeast, the more extensive of these plateaus are the St. George's, Western or Sable Island, Banquereau, St. Pierre, and Green Banks, and, most northeastern and by far the largest, the Grand Bank of Newfoundland.

St. George's Bank, more frequently called simply George's Bank by the Gloucester fishermen whose fleet of hundreds of schooners is mostly employed in fishing there, extends a hundred and seventy five miles east from Nantucket and Cape Cod, being connected with the Nantucket shoals by an isthmus which has about 40 fathoms of water. The area of St. George's Bank above the 50 fathom contour line exceeds that of the State of Massachusetts, and has a width of about a hundred miles from northwest to southeast. George's Shoal, on the northwestern part of this plateau, has two spots with only 12 feet of water; while twenty miles west from that highest portion of St. George's Bank, it rises again in the Cultivator Shoal to 18 feet, or only 3 fathoms, below the sea level. About these shoals the ground swells of great storms break with nearly as much grandeur and danger to shipping as on a coast line. The surface of the bank, as shown by the soundings of the U. S. Coast Survey, "is covered with pebbles and small stones, excepting shallow portions and pot-holes, where the material ground down by the sea has accumulated."*

North of St. George's Bank, the Gulf of Maine occupies an area of about 36,000 square miles, of which nearly a third part exceeds 100 fathoms in depth, the average for the whole being estimated not less than 75 fathoms. The maximum depth of the western part of the Gulf of Maine is 180 fathoms, found 46 miles east of Cape Ann; and of its eastern part, at a distance of a hundred miles east-southeast from the last, 199 fathoms, this being close north of George's Bank, in latitude

* "Physical hydrography of the Gulf of Maine." Report of the U. S. Coast and Geodetic Survey, for the year ending June, 1879, pp. 175–190. "A plea for a light on St. George's Bank." Appendix No. 11, ibid., for year ending June, 1885, pp. 483–485. The contour of the Fishing Banks, as here described, is shown by Eldridge's Chart from Cape Cod to Belle Isle, 1887 (published by S. Thaxter & Son, 125 State St., Boston).

42° 20′ and longitude 67° 20′. At the mouth of this gulf, between the northeastern border of George's Bank and Brown's Bank, of comparatively small area, which lies halfway thence to Cape Sable, N. S., the soundings are from 150 to 170 fathoms.

Brown's Bank is covered by water from 26 to 50 fathoms deep, and on its north side water of 60 to 80 fathoms divides it from Nova Scotia. Three other small plateaus lie within the next hundred and fifty miles eastward.

Continuing in this direction, the large Western Bank and Banquereau stretch two hundred and fifty miles east-northeast, varying from 50 to 75 miles in width, and separated by a breadth of 25 to a hundred miles of deep water from the eastern part of Nova Scotia and from Cape Breton Island. On the east half of the Western Bank its highest portion is the wave-built broad sand beach of Sable Island, about 25 miles long from west to east, heaped in dunes by the winds. Between Banquereau and Cape Breton Island are some half a dozen small banks, of which the Misaine, about sixty miles long, is the largest and extends farthest northeast.

Next eastward the now deeply submerged preglacial valley of the River St. Lawrence lies at a depth of 260 to 300 fathoms, showing, as Prof. J. W. Spencer has well pointed out, that before the Ice age this part of North America was elevated at least from 1500 to 2000 feet above its present height.*

Beyond this great submarine valley the St. Pierre Bank, covered by only from 22 to 50 fathoms of water, reaches about a hundred and twenty-five miles from northwest to southeast, with a width of 30 to 60 miles. On the north this bank is divided from the Miquelon Islands by water from 61 to 63 fathoms deep.

Soundings of from 80 to 96 fathoms separate the St. Pierre from Green Bank, of which the latter has a length of about 60 miles from north to south with half as great width, being in its turn separated from the Grand Bank by water of 64 fathoms. Farther east the deep water between Cape Race, Newfoundland, and the Grand Bank is mostly from 80 to 100 fathoms, and in one place 115 fathoms. On the northwest, however, Placentia Bay of Newfoundland has maximum soundings of from 125 to 147 fathoms, being thus probably 67 fathoms deeper than any outlet from it to the depths of the North Atlantic.

The Grand Bank has approximately the outline of an equilateral triangle measuring from 275 to 300 miles on each side,

* "The high continental elevation preceding the Pleistocene period." Bulletin G. S. A., vol. i, 1890, pp. 65–70, with map of the preglacial Laurentian river. Also in the Geol. Mag., III, vol. vii, 1890, pp. 208–212.

or very nearly the same as the far more irregular area of Newfoundland. Its depth of water ranges mainly from 25 to 50 fathoms, and its shallowest places are found along the northern edge, on which are the Virgin Rocks, with only from 4 to 10 fathoms; the rocky eastern shoals, stated to be 30 in number, with from 5 to 25 fathoms, but having channels of from 40 to 50 fathoms between them; and, farther east, Ryder's Bank, with only 3½ fathoms, though surrounded by from 38 to 40 fathoms of water. The western part of the Grand Bank contains an apparently enclosed basin, about fifty miles long, called Whale Deep, which has maximum soundings of from 60 to 67 fathoms, with a muddy bottom. Northward from this basin a distance of twelve miles, with soundings from 48 to 53 fathoms, divides it from the deep water outside the bank; and on the south 30 miles, with mostly about 50 fathoms of water, lie between the Whale Deep and the steep descent into the abyssal ocean.

If this portion of the continental border from Cape Cod to the Grand Bank southeast of Newfoundland could be again uplifted as when the St. Lawrence in preglacial times flowed out to sea between the highlands which now form the Misaine, Banquereau, and St. Pierre Banks, we should behold nearly as much diversity of valleys, ridges, hills, plateaus, and all the forms of subaërial land erosion, as is exhibited by any portions of the adjacent New England states and eastern provinces of Canada. During a long time of high elevation closing the Tertiary era and initiating the Quaternary, this region was eroded by rains, rills, brooks, and rivers, cutting such profound chasms as the sublime Saguenay fjord, reaching 800 feet below the sea level and enclosed by precipitous rock walls, 1500 feet high, until the cold climate induced by the increasing altitude covered the land with an ice-sheet which gradually became thousands of feet thick and at last by its weight appears to have brought about the Champlain depression, the return of a temperate climate, and the final melting of the ice. The submerged channels of outlet from the Gulf of Maine and the Gulf of St. Lawrence, and the less profound valleys that divide the Fishing Banks from each other and from Nova Scotia and Newfoundland, with the distinct stream courses revealed by soundings on all the larger banks, as St. George's, Western, Banquereau, St. Pierre, and the Grand Bank, prove that this region during a comparatively late period of geologic time was a land area, its maximum elevation being at least 2,000 feet higher than now.

That the period of uplift was the late Tertiary and early Quaternary is shown by the age of the strata which, beneath a thin envelope of glacial drift, form these submarine banks. In

1877 Prof. C. H. Hitchcock suggested that the Fishing Banks are of Tertiary age;* and much earlier Agassiz had taught his classes that they must consist superficially of drift, the eastern continuation of the drift sheet of the northern United States and of Canada. Both these theories were fully justified in 1878, when in the service of the U. S. Commission at Gloucester, Mass., I gathered from the fishermen of that port many specimens of rocks that had been brought up from the bottom of the Fishing Banks by their lines becoming entangled in the coralline growths attached to these rock masses. A large proportion of the stones so drawn up are rounded and subangular fragments of granitic, gneissic, and schistose rocks, evidently transported to their present position through the agency of ice, either by an ice-sheet during the Glacial period, as was doubtless true for a large part of this drift, or by icebergs and floes, which still are contributing yearly to the drift of the Grand Bank. Apparently a smaller proportion, but more likely to be brought ashore by the fishermen, consists of fossiliferous sandstone and limestone, often well filled with shells or with their empty casts. Many of these fossiliferous rock fragments, varying from one pound to a hundred pounds or more in weight, were collected and submitted to Prof. A. E. Verrill for determination of their species, concerning which he wrote as follows in this Journal for October, 1878 (III, vol. xvi, pp. 323–324).

Among the most important results of the investigations made by the party connected with the U. S. Fish Commission, stationed at Gloucester, Mass., during the present season, is the discovery of fragments of a hitherto unknown geological formation, apparently of great extent, belonging probably to the Miocene or later Tertiary. The evidence consists of numerous large fragments of eroded, but hard, compact, calcareous sandstone and arenaceous limestone, usually perforated by the burrows of *Saxicava rugosa*, and containing in more or less abundance fossil shells, fragments of lignite, and in one case a spatangoid sea-urchin. Probably nearly one-half of the species are northern forms, still living on the New England coast, while many others are unknown upon our coasts and are apparently, for the most part, extinct. From George's Bank about a dozen fossiliferous fragments have been obtained, containing more than twenty-five distinct species of shells. Among these one of the most abundant is a large thick bivalve (*Isocardia*) much resembling *Cyprina Islandica* in form, but differing in the structure of the hinge. This is not known living. *Mya truncata*, *Ensatella Americana*, and the genuine *Cyprina* are also common, together with a large *Natica*, a *Cyclocardia* (or *Venericardia*) allied to *C. borealis* (Con.), but with

* Geology of New Hampshire, vol. ii, p. 21.

smaller ribs, *Cardium Islandicum*, and also various other less common forms. These fragments came from various parts of the bank, including the central part, in depths varying from 35 to 70 fathoms, or more.

From Banquereau, N. S., we received one specimen of similar rock, containing abundant fragments of a large bivalve, and about a dozen other species, among which are *Fusus* (*Chrysodomus*) *decemcostatus*, *Latirus albus* Jeff. (?), unknown species of *Turritella*, etc. From the Grand Bank two similar specimens were received. One of these, from thirty-five fathoms, lat. 44° 30′, long. 50° 15′, contained numerous specimens of *Cyprina Islandica* in good preservation.

. . . . . .

At present it appears probable that these fragments have been detached from a very extensive submerged Tertiary formation, at least several hundreds of miles in length, extending along the outer banks, from off Newfoundland nearly to Cape Cod, and perhaps constituting, in large part, the solid foundations of these remarkable submarine elevations.

The collections here described, belonging to the U. S. Fish Commission, are under Professor Verrill's care in the Yale University museum; but no further investigation of them has been made. It has been my hope to secure another similarly large collection and to give it attentive study, but other duties have prevented this. Though the fishermen doubtless now draw up on their lines as many of these specimens of the bed-rocks of the banks as they did fifteen years ago, most of them are immediately thrown away and fewer are brought ashore than at that time when the work of the Fish Commission in Gloucester stimulated a worthy rivalry among the captains and fishermen to bring in everything zoological or geological which might possibly be of scientific interest for the Fish Commission. Visiting Gloucester during a few days in the summer of 1890, my only opportunity for this collecting within recent years, I was able to obtain only a few specimens of these fossiliferous rocks, chiefly through donation by Dr. Thomas Conant and Mr. Everett P. Wonson of that city, half of which I have transmitted for these donors to the museum of this Society and the other half to that of Dartmouth College. These specimens were brought from St. George's Bank, and were mostly from depths of about 40 fathoms.

By date of September 29, 1890, Professor Verrill wrote as follows, in reply to my inquiries concerning the Fish Commission collection of the fossiliferous bed-rocks of the Fishing Banks: "I have found it useless to try to work up the fossils till the recent shells from the same region are better known. We have already added more than 200 species to the list of the

shells of the banks and their vicinity, and have many others on hand not yet described. Probably many of the fossils may be identical with these newly recorded or unrecorded species, but a very long and laborious study can alone determine how many are recent, owing to their imperfect condition." In the light of this lately added knowledge of the fauna of our submarine continental border,* it seems very probable that these rocks will prove of Pliocene rather than Miocene age. Their uplift and subaërial erosion took place, therefore, as already indicated in the preceding part of this paper, at the close of the Tertiary era and immediately before the Glacial period.

The Fishing Banks are thus to be accounted, like the fjords of all our northern coasts, the submerged continuation of the Hudson River channel, and the similar very deep submarine valleys off the shore of California near Cape Mendocino, to which I have previously called attention,† as evidence of a great epeirogenic uplift of the northern part of this continent preceding and producing the Ice age.

NOTE.—Referring to Mr. J. B. Woodworth's suggestion in this Journal for Jan., 1894, p. 71, that pebbles carved by wind-blown sand should be looked for among the stones dredged from the Fishing Banks, it should be borne in mind that the high uplift exposing these areas to subaërial erosion was preglacial, and that when the ice-sheet disappeared the coast from Boston to Nova Scotia was depressed somewhat below its present height. Although this depression of the land probably carried the Fishing Banks and the border of the ice-sheet there below the sea level, a small postglacial uplift of the seaboard, which is known to have raised the land at the head of the Bay of Fundy at least 80 feet higher than now, may have laid bare considerable parts of the Fishing Banks so that their present surface stones could be worn by drifting sand dunes. (See former articles in this Journal, III, vol. xxxvii, pp. 359–372, May, 1889, and vol. xliii, pp. 201–209, March, 1892.)

* Previous to 1870 the known molluscan fauna of the seas of northeastern America comprised about 290 species; but now, according to Prof. Verrill, it numbers 500 or more. In comparison with this we may note that the British Isles have about 600 species of marine mullusks, and the whole of Europe about 800. (Prestwich's Geology, vol. i, pp. 120–121).

† "Probable Causes of Glaciation." Appendix of Wright's Ice Age in North America, 1889, pp. 573–595. Bulletin G. S. A., vol. i, 1890, pp. 563–567. Amer. Geologist, vol. vi, Dec., 1890, pp. 327–339.

# SCIENTIFIC INTELLIGENCE.

## I. Chemistry and Physics.

1. *On the Fusing points of Inorganic Salts.*—The first results of an investigation made by V. Meyer and Riddle to determine the fusing points of certain of the more refractory inorganic salts, and thereby to ascertain what relation if any exists between these points in the case of allied salts, have been recently published. The salts thus far investigated are the chlorides, bromides, iodides and sulphates of sodium and potassium. In order to measure accurately the high temperatures in question, the authors made use of the following method: The salt under examination was placed in a large crucible of platinum and by means of a Perrot furnace, was heated to a point considerably above that of fusion. The crucible was then removed from the furnace and an air thermometer, made of platinum and constructed on the compensation principle, was inserted into the still melted salt. As soon as solidification commenced, the temperature remained constant for a considerable time during which the air in the thermometer was displaced by hydrogen chloride gas. By measuring the volume of this gas by absorption in water, the temperature could be calculated. In this way it was found that the chloride, bromide and iodide of sodium fuse at 851°, 727° and 650°, respectively; the corresponding salts of potassium melting at 766°, 715° and 623°. So that it appears that a lowering of the fusing point is a consequence of an increase in the atomic mass, either of the metal itself or of the halogen elements. Potassium oxide moreover, fuses at 1045° and sodium oxide at 1098°. But in the case of the sulphates, while the sodium salt melts at 843°, the potassium salt melts at 1073°; a result which differs from the law based on the behavior of the halogen compounds, although it agrees with certain other differences already noticed between the behavior of the oxy-salts of sodium and potassium and the haloid salts of these metals.—*Ber. Berl. Chem. Ges.*, xxvi, 2443, November, 1893. G. F. B.

2. *On the Manocryometer.*—A new instrument has been devised by De Visser for the purpose of determining the melting point of a substance under pressure, which he calls a "manocryometer." It consists of a stout glass vessel somewhat resembling Ostwald's modification of the Sprengel density tube; only the shorter capillary tube is sealed off and the longer one is provided with two small bulbs on the ascending portion, the horizontal part, which is sealed at the end, being very long. The principal bulb is filled with the substance to be experimented on, the lower part of the capillary tube and the lower bulb are filled with mercury and the rest of the capillary tube is filled with air which acts as a manometer. The substance is heated to a temperature a little above its melting point for half an hour and the pressure is then

read off. By this means the value $dT/dp$ is obtained, in Professor James Thomson's equation for the variation of the fusing point with pressure

$$\frac{dT}{dp} = 10333 \cdot \frac{T}{E} \cdot \frac{\sigma - \tau}{r}$$

in which T is the fusing point, $p$ the pressure, $\sigma$ the specific volume of the liquid, $\tau$ that of the solid, both at the melting point, and $r$ the heat of fusion at the melting point. The author determined the values of $dT/dp$, T, $\sigma$, $\sigma-\tau$ and $r$ for acetic acid and also the value $(\sigma-\tau)/r$ directly by means of an acetic acid calorimeter. For the melting point of this acid T at $760^{mm}$ he finds 16·6713° by the mercury thermometer and 16·5965° by the hydrogen thermometer. For the density of the liquid at the melting point, he obtains 1·05315 compared with water at 4°; and hence the specific volume $\sigma$ is 0·94953. Since the change of volume on fusion of one kilogram in cubic meters $\sigma-\tau$ is 0·00015955, the specific volume of the solid at its melting point is 0·78998 or its specific gravity is 1·26585. The heat of fusion at the melting point $r$ was found to be 46·416 calories. The calculated value of $(\sigma-\tau)/r$ was 0·0000034374; that found directly being 0·0000034425. The value of $dT/dp$ as calculated was 0·02421° as compared with 0·02435° found with the manocryometer.

The author has also described an interesting lecture experiment with the manocryometer. A tube of $2^{mm}$ interior diameter having walls $6^{mm}$ thick, is sealed off at one end and drawn out to a capillary size at the other, the whole being about $15^{cm}$ long. This tube is immersed in pure acetic acid and filled by alternately exhausting it and plunging its open end into the acid. It is then inverted and the capillary end being plunged into acetic acid, the wider end is cooled by surrounding it with cotton wool on which ether is dropped. The acid in the tube solidifies with considerable diminution of volume, fresh acid being drawn into the tube in consequence. When the greater portion of the acid is solidified the capillary end is withdrawn from the acid and the cooling is continued until some air has entered. The end is then sealed and the tube is ready for use. It is now suspended in a beaker of water the temperature of which is gradually increased. At the ordinary pressure acetic acid melts at 16·6°; but when it is thus confined in a closed space, it creates a greatly increased pressure as it melts, and thereby raises the melting point of the remaining solid. In this way the author has succeeded in raising the fusing point as high as 40° corresponding to a pressure of about 100 atmospheres. When these tubes break they do not explode but crack lengthwise.—*Rec. Trav. Chim.*, xii, 201, 154; *J. Chem. Soc.*, lxiv, ii, 563, 566, Dec., 1893. G. F. B.

3. *On the Fusion and Volatilization of Metals and Oxides in the Electric Arc.*—In continuing his researches on chemical reactions at high temperatures, Moissan has exposed various metals, salts and oxides to the heat of his electric arc furnace. To con-

dense and collect the substances that sublime, a copper U-tube through which a rapid current of cold water flows, is placed in the furnace immediately over the crucible, and is surrounded with asbestos card-board. Magnesium pyrophosphate exposed for five minutes to the arc produced by a current of 300 amperes and 65 volts gives a sublimate of magnesium oxide and ordinary phosphorus. Asbestos with 300 amperes and 75 volts almost completely volatilizes in a few minutes leaving only a small residue of fused silicate and a globule of magnesium silicide. Copper with 300 amperes and 70 volts volatilizes rapidly and condenses in globules. In contact with air its vapor forms cupric oxide. Silver enters into ebullition and distills readily, condensing in fused globules, gray amorphous powder and arborescent fragments. Platinum melts almost immediately and very soon begins to volatilize, condensing in brilliant globules and as a powder. Aluminum with 250 amperes and 70 volts also volatilizes and condenses in small spherules. Tin with 380 amperes and 80 volts volatilizes readily and condenses in small globules and in fibrous masses. Gold with 360 amperes and 70 volts volatilizes in six minutes to a considerable extent, condensing in small spheres. Manganese, with 380 amperes and 80 volts volatilizes very readily; only a small residue of carbide being left from 400 grams of the metal, after ten minutes. Iron with 350 amperes and 70 volts volatilizes and condenses as a gray powder mixed with brilliant malleable scales. Uranium with 350 amperes and 75 volts readily volatilizes and condenses in small non-magnetic spheres free from carbon. Silicon volatilizes with 380 amperes and 80 volts and condenses in small spheres mixed with a gray powder and a small quantity of silica. Carbon with 370 amperes and 80 volts rapidly changes into graphite and then volatilizes, condensing in very light thin translucent maroon-colored plates, similar to or identical with the maroon-colored variety of carbon noticed by Berthelot, and burning in oxygen readily. Calcium oxide with 350 amperes and 70 volts volatilizes after 8 or 10 minutes and with 400 amperes and 80 volts it volatilizes in five minutes. The oxide condenses entirely as an amorphous powder. With 1000 amperes and 80 volts, 100 grams of the volatilized oxide can be obtained in 5 minutes. Magnesium oxide volatilizes with more difficulty than calcium oxide and its boiling point is near its melting point. With 360 amperes and 80 volts it gives off a quantity of vapor; distillation becoming very rapid with 1000 amperes and ten volts.

Moissan has also submitted zirconia and silica to the electric arc. When zirconia is heated in an electric arc with a current of 360 amperes and 70 volts it rapidly melts and in about ten minutes is in complete ebullition giving off thick white vapors which condense to a white powder consisting of opaque microscopic granules which scratch glass and possess all the properties of zirconia, having a specific gravity of 5·10. The residue in the crucible has a crystalline fracture. In the cooler parts of the

furnace dendritic crystals of zirconia are deposited. If the zirconia be fused in a carbon crucible under these conditions, a button of zirconium mixed with some zirconia but free from carbon and nitrogen is found beneath the non-volatilized oxide. When the zirconia is mixed with an excess of carbon a zirconium carbide is obtained containing from 4·22 to 5·10 per cent of carbon. It has a metallic appearance and a brilliant fracture, and when fused with an excess of zirconia yields pure zirconium of specific gravity 4·25 which scratches glass and rubies easily and resembles closely the zirconium described by Troost. If the carbide contains more than 5 per cent of carbon, it inflames somewhat rapidly when exposed to the air. Silica in an arc of the same intensity melts almost immediately and is in complete ebullition after six or seven minutes. The vapors condense to a slightly bluish white powder consisting of a mixture of amorphous silica with small opalescent spheres which scratch glass easily and have a specific gravity of 2·4. About 20 grams of silica can be volatilized in from 10 to 15 minutes, the condensed product being very easily attacked by hydrogen fluoride and by alkalies. Under these conditions, silica is also reduced by carbon, yielding a crystalline silicon carbide.

Troost has suggested the utilization of the volatility of silica for the purpose of separating it from zirconia or thoria. If finely pulverized zircon be mixed with an excess of carbon, compressed into small cylinders, placed in a carbon disk and subjected to the action of an electric arc in a closed vessel through which a current of carbon dioxide is passed, the silica volatilizes very rapidly, giving a thick black smoke due probably to silicon. The residue contains only 1·5 per cent of silica. Similar results were obtained with thorite and orangite, the separation of the silica in this way greatly facilitating the preparation of the thoria.—*C. R.*, cxvi, 1222, 1428, 1429, 1893; *Ber. Berl. Chem. Ges.*, xxvi (Ref.), 482, 669, July, Oct., 1893. G. F. B.

4. *Modification of Thomson's quadrant electrometer.*—F. Himstedt describes a multicellular electrometer with one or two simple modifications. The needle is suspended by a quartz or glass fiber which is slightly silvered in order to conduct. For the purpose of damping the movements of the needle, an astatic system consisting of two magnets is suspended from a wire, which forms the continuation of the axis of the needle system. These magnets are placed vertical, and are surrounded by a copper cylinder. The earth's directive force is annulled and the movements of the needle system is damped by the presence of the copper cylinder.

The multicellular electrometer was first used in the Jefferson Physical Laboratory in 1885, and the original instrument is now in the Signal Service Bureau at Washington.—*Ann. der Physik und Chemie*, No. 12, 1893, pp. 752–755. J. T.

5. *Coating aluminium with other metals.*—At a meeting of the Physical Society, Berlin, Dec. 1, 1893, Professor Neesen de-

scribed a method of coating aluminium with other metals. The aluminium is first dipped in a solution of caustic potash or soda or hydrochloric acid until bubbles of gas make their appearance on the surface. Then it is dipped in a solution of corrosive sublimate in order to amalgamate the surface. Afterward it is dipped again in caustic potash till gas is evolved. Then the metal is placed in a solution of the salt of the desired metal. A film of the latter is soon formed and is so strongly adherent, that in the case of gold, silver and copper, the plate can be rolled or polished. The coated aluminium can be soldered with ordinary zinc solder. When a coating of gold or copper is desired, it is best to coat first with silver. J. T.

6. *Modifications of Silver.*—H. LÜDKE discusses the various methods of depositing silver, and investigates the properties of the films. He concludes: that Lehmann's hypothesis that a thin layer of silicate of soda on glass is concerned electrolytically in the process of silvering on glass—is not true, for mirror silver is separated on mica porcelain quartz, fluorspar-platinum, etc. The electrical resistance of many kinds of mirror silver decreases.

Mirror silver produced however by reduction with sugar of milk, according to Liebig's method, or according to Martin's process, show no decrease of resistance. Heat, light and chemical action can easily change allotropic mirror-silver into other good conducting modifications. Mirror-silver gives with ordinary silver, scarcely any difference of electromotive force. Mirror-silver in its original unchanged condition, is similar to colloidal silver.—*Ann. der Physik und Chemie*, No. 12, 1893, pp. 678–695. J. T.

7. *Vorlesungen über Maxwell's Theorie der Elektricität und des Lichtes*, von DR. LUDWIG BOLTZMANN. II Theil, 166 pp. 8vo. Leipzig, 1893 (Johann Ambrosius Barth—Arthur Meiner).—The appearance of the first part of this important work was noticed in this Journal about a year and half ago and the scope of the author's plan was then remarked upon. The present part contains the discussion, from the standpoint of Maxwell's theory, of action at a distance with the special cases of electrostatic distribution and induction.

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ERRATA, in Prof. Mayer's article of "Researches in Acoustics, Paper No. 9," this Journal Jan., 1864.

Page 2, line 9 from bottom for *the* read a.

Page 3, 10 lines from bottom, for *duration or the after-sensation* read duration *of* the after sensation.

Page 4, line 20 from bottom *dele* (;).

Page 7, line 8 from bottom for *center*, read centers.

Page 12, line 2 from top for *tube*, read tubes.

Page 14, line 4 from top *dele end of the.*

Page 21, line 17 from top for *dessons*, read dessous.

Page 21, line 11 from bottom for *dessau.* read dessous.

Page 24, line 7 from top for *vibrate*, read vitiate.

## II. Geology and Mineralogy.

1. *The Geological Society of America.*—The sixth annual meeting of the Geological Society was held at Boston, Mass., on December 27th and 29th, and at Cambridge on the 28th, 1893. The opening meeting was held in the hall of the Boston Society of Natural History, Sir J. William Dawson, the president of the Society, in the chair. The annual address of the President, on Some Recent discussions in Geology, was delivered Friday evening, Dec. 29th. A lecture by Alexander Agassiz, giving an account of an expedition to the Bahamas, was read before the society on Wednesday evening.

The following officers for the year 1894 were elected, viz: president, T. C. Chamberlin, Chicago; first vice-president, N. S. Shaler, Cambridge; second vice-president, G. H. Williams, Baltimore; secretary, H. L. Fairchild, Rochester, N. Y.; treasurer, I. C. White, Morgantown, Va., and editor, J. Stanley Brown, Washington, D. C.

There were fifty-one fellows in attendance and fifty-eight papers were presented for reading.

The following notes indicate briefly the contents of some of the papers read.

Sir J. William Dawson, in his presidential address, on *Some Recent Discussions in Geology:* defined the attitudes of geological opinion regarding some of the live questions of to-day, speaking of them as the goals of to-day which are to be the starting points of the researches of to-morrow. In regard to the age of the crystalline rocks he spoke of the lower Laurentian gneisses as probably of igneo-aqueous origin and as the oldest known rocks. In regard to the theories of mountain making he was disposed to think that the action of all the forces emphasised in LeConte's contraction theory, in Hall's deposition theory, in the expansion theory of Reade, and in Dutton's isostatic theory must be considered in reaching the truth.

In the catastrophe—uniformitarian controversy harmony was to be looked for by recognizing the fact that what appears as a catastrophe may be but the culmination of uniformly working laws.

He referred to the fact that organic matter, as in the case of coal, is of slow and gradual accumulation, and is not peculiar to any particular age though a prominent feature in the Carboniferous era. He showed that fossil plants by their distribution are evidence that the vicinitudes of climate in the geological ages were mainly due to the differences in the distribution of land and water. In explanation of the phenomena of the glacial age, he maintained that "local glaciers of great magnitude on elevated ground and depression of lower lands beneath the sea were mainly responsible for this icy episode." He believed that there was an open Polar Sea throughout the glacial age, and that sea-

borne ice as well as glaciers must be looked to, to account for the known evidences of glaciation.

In a paper on *New discoveries of Carboniferous Batrachians*, the same author gave an account of the mode of preservation and gradual accumulation of the remains of land animals and insects in the hollow trunks of trees buried in aqueous deposits, as illustrated by the buried Carboniferous trees of the South Joggins section, several new specimens of which have been recently developed.

The paper by G. W. Dawson was read in his absence by the president of the Society. It consisted of *Geological notes on some of the coasts and islands of Behring Sea and its vicinity*, made during his visit to the regions as one of the members of the British Commission investigating the fur-seal problem in 1891.

The localities visited were the Aleutian Islands, Komandorski Islands, Kamtschatka, Pribyloff Islands, Nunivak Island, St. Matthew Island, Plover Bay. Many of the islands are of volcanic origin, and the whole line of islands were found to be on the outer border of the continental plateau, which, elevated above its present level, once connected Asia and Alaska. The author concluded, from his study of the soundings and of the Tertiary formations on the edges of some of the islands, that the submarine plateau and the western part of Alaska were under a shallow sea during the later Miocene epoch, since which time the region was elevated, forming land connection between the two continents by which the mammoth may have reached the Pribyloff Islands. This was followed by depression, and in comparatively recent times there was an elevation of 10 to 30 feet.

The observations of Dr. Dall and others as to the absence of any evidence of general glaciation in the Behring Sea region are confirmed by the author's observations.

*The eastern boundary of the Connecticut Triassic.*—Profs. W. M. Davis and L. S. Griswold, in their paper, illustrating the general structural features of the Triassic belt by a series of lantern slides, maintained that the eastern boundary of the formation is defined by a system of faults, whose existence is proved, according to the authors' interpretation of the facts, as follows: First, different members of the formation successively terminate along the eastern border; in passing northeastward from the Sound near East Haven, to the Connecticut River near Middletown, the lower sandstones, the anterior trap sheet, the anterior shales, the main trap sheet, the posterior shales and sandstones, the posterior trap sheet and the upper sandstones and conglomerates, gently undulating as a whole, are terminated in alternating succession along the border. This cannot be explained as a result of variable overlap of the Triassic series unconformably upon the crystallines, for the former dip towards the latter; they must be cut off abruptly along the margin of their present area. The border is marked by a depression, wider open when the adjacent rocks are weak, narrow when they are hard. Close to the border, departures from the prevailing dip of

the formation are frequent. The crystalline rocks near the border manifest the effects of shearing; and this seems to be subsequent to the formation of the marginal conglomerates, for they do not contain fragments of the sheared crystallines.

The eastern boundary follows an alternating north and northeast course. Hence two systems of faults may be recognized; one having a northerly course, the other trending northeast. Two members of the latter system have been traced for many miles obliquely across the Triassic belt, as well as along the oblique portions of the border. In consequence of the combined movements of both systems of faults, the formation broadens to the north; and in the Manchester district, it is believed that the under sandstones, ordinarily seen along the western border of the monoclinal belt, are repeated along the eastern border. (Author's abstract.)

In his paper on *The fossil flora of Alaska*, F. H. KNOWLTON reported the total number of species listed as 114, of which the 54 species more recent than Neocomian occur also outside of Alaska. The author gave the following conclusions:

"An examination of the table yields the following numerical results: The Laramie has 3 species of which 1 is doubtful; post-Laramie beds of Colorado 10 species; the Livingston beds of Montana 6 species; the Ft. Union beds 16 species of which 1 is doubtful; the Green River group 9 species of which 3 are in doubt; the Mackenzie River 11 species; British Columbia has 6 species in the Miocene and 4 in the Laramie with 2 common to both; California, represented by the Auriferous gravels and allied formation has 17 species of which 3 are in doubt; the Eocene (Alum Bay, etc.) 6 species; the Greenland Miocene, as represented at Disco Island, Atane Rerdluk, etc., has 29 species; the Miocene of Spitzbergen 20 species; the island of Sachalin (Siberia) 23 species; Senizalia (Italy) 12 species; the so-called Baltic Miocene 13 species; Oeningen 20 species; Oligocene 4 species; Miocene 33 species; Pliocene 15 species.

"By combining a number of the above localities which may be legitimately taken together we have still more impressive results. Thus by the combining of the post-Laramie beds of Colorado with the Livingston beds of Montana we have 13 species common to Alaska. The union of the Mackenzie River and Ft. Union deposits gives 21 species common to Alaska, while Greenland, Spitzbergen and Sachalin have no less than 39 species out of the 54 from Alaska.

"This last result shows, if we are to place any dependence in fossil plants, that the flora of Alaska, Greenland, Spitzbergen and the island of Sachalin are so closely related as to lead to the unavoidable conclusion that they grew under similar conditions and were synchronously deposited. The localities enumerated show that the circumpolar flora at that time was practically similar and continuous."

N. S. SHALER presented three papers, of which the following abstracts give the substance.

1. *Notes on the Pleistocene dislocations of the Atlantic Coast of the United States.*

The dislocations of the Cretaceous, Tertiary and Pleistocene strata of northeastern Massachusetts described by the writer in the Seventh Annual Report of the director of the U. S. Geol. Survey, p. 297, et seq., and in the Bulletin of the Geol. Soc. of Am., vol. i, p. 443 et seq., appear to be a part of a mountain-building process which, in relatively recent times since the beginning of the Pleistocene, has affected the Atlantic coast from North Carolina to Massachusetts Bay. South of New York the type of the dislocations have the fault type, north and east of the Hudson they take on the character of foldings. These movements, though extensive and intense in southern New England, appear to have satisfied the stresses which caused them, for since the development of the topography of the district, so far as it was formed on these dislocated rocks, no considerable movements have taken place.

The foldings of the rocks in the Cretaceous, Tertiary and Pleistocene strata of Martha's Vineyard and neighboring districts, seem to have been due to the formation of a broad, rather compressed synclinal in the crystalline rocks upon which they rest; in this respect resembling the down-fold which encloses the Richmond, Va., coal field.

The disturbed strata of the New England shore district are now at about the level in which they were formed. There thus appears to have been no considerable permanent change of level of this part of the continent due to their orogenic action. (Author's abstract.)

2. *Relation of Mountains and Continents.*

Modern investigations show that mountains do not develop on the deep sea floors in the manner in which they are formed on the continental folds. This shows that there is some causal relation between these two types of relief.

An inquiry into the sub-aerial reliefs of the great coasts shows that they are in the main, made up of the broad pedestals which have been formed in the districts where mountain building has occurred. The mass of these pedestals, or regional uplifts is generally very great. They indicate the movement of inner earth matter toward the seats of dislocation : a large part of the material going to form the uplifted section of the earth's crust on either side of the mountain-built area. A part of this pedestal is in many cases formed of debris worn from the central axes.

Deep-sea soundings show that there are folds of the crust formed in the thalassal areas. Although the number and precise shape of these folds is unknown, it seems not improbable that they are the original type of surface deformations. When one of these ridges attained a supra-marine level, local erosion, with

the consequent transfer of weight, brought about the mountain-building disturbances and thus served to determine the form and in part the elevation of the fold.

The history of the peninsula of Florida, the promontory of Yucatan and the Cincinnati axis appear to give support to this view as to the relation of mountains and continents. (Author's abstract.)

3. *Phenomena of beach and dune sands.*

The remarkable endurance of beach sands to the blows which are inflicted by the waves is to be explained by the fact that when mineral matter attains a certain state of division being thoroughly wet, a film of water is usually held between the adjacent grains which serves to keep the surfaces apart and thus, in a great degree, prevents abrasive action. Thus, while pebbles wear rapidly in the mill of the surf, sand is very little worn.

The effect of sea-weeds in bringing pebbles and sand into the beaches is very great: this is accomplished by the floating action of these plants on the objects to which they become attached in the shallow water near the shore.

The effect of floating pumice which becomes stranded along the Atlantic coast is, at certain points, noticeable; but the enquiries as to the value of the contribution have been retarded by the difficulty which has been found in determining in a ready way the difference between certain forms of furnace slag from steamship boilers and true volcanic materials.

The movement of dune sands is to a great extent made possible by the fact that these accumulations of sand rarely become wet through, except it may be during the winter season. A rain-fall of an half an inch will in general moisten the sands to the depth of not over three-fourths of an inch. The water flows laterally to the center of the depressions and there only finds a passage to the deeper parts of the dune. The result being that in a short time the materials are dry enough to be set in motion by the wind.

The large amount of fine dust developed in dune sands, which have been some time stable, shows the rapidity with which the processes of decomposition of their materials advance. (Author's abstract.)

Wm. B. Scott discussed the *Lacustrine Tertiary formations of the West* and gave the paleontological reasons for separating the Paloduro beds from the Loup Fork proper.

The classification of the Neocene formations (fresh water) of the United States, proposed as the result of his latest studies, is given in the following table (first published in Princeton College Bulletin, vol. v, Nov., 1893, p. 84):

| | | |
|---|---|---|
| Pliocene | | Peace Creek (Florida). |
| | | Blanco. |
| | | Paloduro (and Archer of Florida). |
| Miocene | Loup Fork | Loup Fork proper. |
| | | Deep River. |
| | John Day | Mesoreodon Beds (Montana). |
| | | Eporeodon Beds (Oregon). |
| Oligocene. | White River | Protoceras Beds. |
| | | Oreodon Beds. |
| | | Titanotherium Beds. |

GEORGE H. WILLIAMS, in his paper entitled, *Volcanic Rocks in the ancient crystalline belt of Eastern North America*, called attention to the widespread occurrence of truly volcanic rocks in the paleozoic and pre-paleozoic formations of eastern North America. He was led to a search for such rocks by the discovery of their extensive development in the Blue Ridge between Harrisburg, Pa., and the Potomac River, as described in this Journal, Dec., 1892. Since that time personal observation has disclosed great masses of similar rocks on the coast of Maine and in the Carolinas, while the published literature renders probable their abundant occurrence as far north as Newfoundland.

After a review of the opinions prevailing in Europe as to the nature of the differences between ancient and modern volcanic rocks, the author enumerated the criteria necessary for the certain identification of ancient volcanic rocks. While regarding the differences between the products of ancient and modern volcanoes as secondary and therefore non-essential, he considered the proofs that any rocks called *volcanic* (in contrast to plutonic) solidified at or very near the atmospheric surface as very important. A tendency on the part of some geologists to use the word *volcanic*, as synonymous with *igneous* is greatly to be deprecated as introducing only confusion. The former term should be employed, at least in the case of ancient rocks where the external form of the volcano has been destroyed, only for igneous masses whose surface origin is beyond doubt. The most reliable proofs are in the case of acid rocks glassy structures, which in spite of complete devitrification will be preserved, and in the case of basic rock an amygdaloidal or scoriaceous texture. Such structures, while they may rarely occur in narrow dykes which have very rapidly cooled, are essentially characteristic of lava flows, especially if the rocks which exhibit them are of great extent. But even better than these structures as proof of volcanic origin are accumulations of fragmental (pyroclastic) material, tuffs, breccias, agglomerates, etc., stratified either by gravity or water, which accompany such massive effusive rocks. All of these proofs are abundant in the rocks to which the author applies the designation volcanic.

The distribution of ancient volcanic products was traced, either by published accounts or by personal examination of material sent

by friends or collected in the field, from Newfoundland through Cape Breton, Nova Scotia, New Brunswick, and along the coast of Maine as far as the Boston basin. Another more westerly belt may be followed from Gaspé, through the Eastern Townships to Vermont; it appears again near Harrisburg and extends at intervals along the whole extent of the Blue Ridge. The eastern belt appears again in North Carolina, not far from Raleigh and is nearly continuous across the State. (Author's abstract).

In the paper on *The Shasta-Chico series of the Pacific Coast*, J. S. DILLER described several measured sections of the Cretaceous in different parts of middle and northern California. He demonstrated the stratigraphic and faunal continuity of the Shasta-Chico series composed in California of the Knoxville, Horsetown and Chico beds which attain a maximum thickness of 30,000 feet (see this Journal, vol. xl, 1890, pp. 476–8). The differences in the composition of the several sections was explained as due to transgression of the Cretaceous seas during the deposition of the series.

*The geology of southern Indian Territory and northern Texas adjacent to the Red River*, was described by ROBERT T. HILL, showing the remarkable development of Cretaceous and later formations in that region where the typical geographic features of the southern gulf coastal plain, the Texas prairie region, and the Appalachian structure of the Ouachita mountains meet, and where their relations are seen.

Mr. Hill showed the differentiation of the various formations south and westward from this area, and gave a minute description of the Washita division of the Comanche series from the Rio Grande to Red River, its faunal and sedimentary changes, with the zones and hemera of its fossils. The Shoal Creek limestone, capping the Comanche series south of the Brazos, was described as having an entirely distinct fauna from that of the contiguous beds—a fauna entirely new to the North American Cretaceous, consisting of Foraminifera, Coelenterata and Mollusks.

The speaker remarked upon the strong homotaxial resemblance between the great divisions of the Texas Cretaceous formations and those of western Europe, especially the Neocomian, Gault, Turonian and Senonian, although presenting absolutely no similarity to the beds of the pacific region.

The author observed that the Duck Creek chalk and the Kiamitia beds contain the fauna described as Neocomian by Marcou, who was the first to recognize the early Cretaceous age of what are now known as the Comanche series. (From notes by the author).

G. H. WILLIAMS called attention to a work written by *Johann David Schoepff*, an almost forgotten contributor to the geology of this country in the last century. His book, dated 1787, "Beiträge zur Mineralogischen Kenntniss des östlichen Theils von Nord Amerika," is full of very good observations made between Rhode Island and Florida, especially in the Appalachians of Pennsylvania, Maryland and Virginia.

WHITMAN CROSS (*Intrusive sandstone dikes in granite*) mentioned the occurrence, in the area of the Pike's Peak granite mass, in Colorado, of sandstone bodies whose *formal* relations to the granite are perfectly analogous to those of dikes of igneous rock, while the *substance* of the masses in question is purely a clastic mixture, almost wholly of quartz, of fine and even grain, very similar to sandstones of sedimentary origin. (Author's abstract).

A paper by T. C. CHAMBERLIN and FRANK LEVERETT on *Certain features of the past drainage systems of the upper Ohio basin*, will be presented in full in this Journal.

The subject discussed and illustrated by specimens under title of a paper on *Facetted pebbles on Cape Cod*, by W. M. DAVIS has already been referred to in this Journal (vol. xlvii, p. 63) by J. B. Woodworth.

ALPHEUS HYATT made a communication upon "*The Fossils of the Trias and Jura of the Western States*," and exhibited specimens of the fossils; his remarks may be summed up as follows: The discovery of Monotis beds above the Carboniferous in American Cañon, south of Cisco, California, showed the probable existence of the Trias there, but just above these in Sailor's Cañon occurred beds of Daonella which were more doubtful. The Daonellæ, although hitherto considered exclusively Triassic, occurred in part near the upper limits of their distribution in curious association with Ammonitinæ of very doubtful aspect.

These Ammonitinæ are not as a whole like any fauna heretofore described as Triassic. They have a distinctly Liassic facies and with them Dr. Curtice found two specimens of Aptychi of the rugose type, which in Europe have not yet made their appearance below the Upper Lias. For these reasons the speaker considered the age of Daonella beds and Ammonites beds to be doubtful, and stated that until specimens showing the sutures of the Ammonitinae were found this could not be determined with certainty.

The Triassic fossils of Gabb's locality in New Pass Desatoya Mts., and near Walker's Lake in Nevada have been found recently in a collection donated by Prof. Whitney to the Museum of Comparative Zoology, and these prove the identity of the faunas at these two localities with that of the Muschelkalk of the Star Peak Range also in Nevada but farther west.

*Lias.*

The same collection contained Gabb's type of *Arnioceras* (*Amm.*) *Nevadanus* and a *Corniceras*, n. sp. showing the existence of the Lower Lias near Walker's Lake in southwestern Nevada.

A small collection of fossils from Professor Condon, coming from the Blue Mts. of eastern Oregon, showed species identical with those of the Hardgrave Sandstone of Taylorville and with some of the species described by Gabb from near Walker's Lake,

thus demonstrating the presence of the Upper Lias at these three localities, two of them separated by the crests of the Sierra Nevada.

*Upper Jura.*

The Gold Belt fossils were next taken up and discussed. The discovery of Gabb's type of *Ammonites Colfaxi* showed that it was a true Perisphinctes and with other forms of the same genus recently found near Colfax demonstrated the Upper Jurassic age of the rocks on the western slope of the Sierras. The Aucellæ, and the Ammonitinæ of the genera Cardioceras and Perisphinctes, from Mariposa, Calaveras and Tuolumne Counties were represented in collections acquired in the last few years by the U. S. Geological Survey and proved, in his opinion, the Upper Jurassic age of the gold belt series of slates. The species of Cardioceras and Perisphinctes had the common characteristics of the similar forms found in the Upper Jura of the Russian fauna and these occurred in association with similar forms of Aucellæ.

The species of Aucellæ differed as a whole from those of the Knoxville slates in being almost invariably ornamented with radiating striæ. Only one species, the *A. Errington* var. *arcuata*, approximated in outline to the well-known, narrow form of *Aucella Piochi*. This is invariably smooth and as lately demonstrated by Diller and Stanton occurs only in the lower part of the Knoxville slates. The conclusion was thus reached that the fauna of the gold belt series of rocks was Upper Jurassic and younger than that of the Knoxville series. (Author's abstract).

Henry S. Williams read a paper on *Dual nomenclature in Geological classifications*, setting forth the importance of differentiating between the lists of geological formations and the divisions of the time scale. He showed that the former are defined and determined by physical, structural and mineral conditions which are always local and never uniform for any considerable geographical extent; and that the latter, however indefinitely, are always known and defined by particular species or genera of organisms which had a definite life period and hence record an actual determinable point in time.

The imperfection of the present method was illustrated by the case of the Catskill formation, whose place in the scale, and the use of the name has recently been discussed by Hall, Darton, Stevenson, Prosser and the author. The author emphasized the fact that in our common usage there are two entirely distinct sets of facts confused in the nomenclature and classification, called the geological scale; that the confusion and evils arising therefrom are not corrected by merely providing two sets of nomenclature, as the international congress of geologists has done in proposing *group*, *system*, *series*, *stage* with their corresponding chronological terms, *era*, *period*, *epoch*, *age*, so long as there is only a single set of divisions classified. The fact is that the stratigraphical division planes used in defining the formation-

scale, while they do indicate relative superposition locally have only relative time value.

Like the lines in the solar spectrum their position must be known before they can be used as chronological marks. The fossils on the other hand have an intrinsic time value, their characters intimately connect them with what has preceded and what follows them. Like the angle of refraction of the rays of light of each color, each fossil has a normal time value.

Fossils thus become the true criteria of the time scale; but the elements of the formation scale are local accumulations of various kinds of sediments whose place in a geological time scale is determinable only by fossils. The formations of one section will overlap, and differ in composition and limits from those of another section,—the time-scale should be a universal standard, with no overlapping, with divisions, arbitrary it may be, but never duplicated; the marks of which are fossils, changing constantly but in a definite order of sequence.

In the case of the Catskill it was shown that within the limits of the New York system, what is called the Catskill formation, group or period is a geological formation, but is not either an epoch or a period, and that Catskill is not an appropriate name to apply to any division of the time-scale. Thus we may say of the Catskill formation, that in the Genesee section in western New York, the whole of Devonian time is recorded without any trace of the Catskill formation, it is neither above, below or within the Chemung. The whole of Devonian time transpires and includes no such division as a Catskill epoch or period. One hundred miles eastward, the section running through Cayuga Lake, shows at the close of the Devonian, after the cessation of the Chemung fauna, a Catskill formation of several hundred feet thickness. Another hundred miles eastward, across Otsego Co., the section contains (1) rocks of the Catskill formation for the upper third of the upper Devonian, below them (2) a sparsely fossiliferous zone of Chemung—probably its lower part, (3) a modified Ithaca fauna, then (4) the Oneonta formation, which is but a detached zone of the Catskill, next (5) a fauna intermediate between that of the Ithaca and the typical Hamilton, underlain by (6) the Hamilton formation of the middle Devonian. Still further east, along the Hudson River valley, the Catskill formation occupies the whole of upper Devonian interval—and if we go still farther east, in Maine we find rocks which are but the extension of the same formation as the Catskill filling the whole interval from the Oriskany to the Carboniferous; i. e. the upper, middle and most of the lower Devonian system.

In elaborating this dual nomenclature, it was proposed to continue the use, for the formation-scale of the present nomenclature in the manner in which the newer work of the United States Geological Survey is being defined, using geographical names in combination with lithological terms for the nomenclature. For the time-scale, the degree of precision increases in the opposite

direction—from the general to the particular. A single fossil in most cases is sufficient to determine the time (Paleozoic, Mesozoic or Cenozoic) to which the formation belongs. The times may be divided into Eras, the Cambrian, Silurian, Carboniferous, etc. Refinement in general usage has proceeded far enough to permit the recognition of two-fold or three-fold divisions of the eras, and these may be designated by prefexing *eo*, *meso* and *neo* to the name of the era, and may be called Periods; thus *Eocambrian* is the name of the period of the Olenellus fauna, *Mesocambrian*, is the period of the Paradoxides fauna, *Neocambrian* the period of Dicellocephalus fauna—and so on for each of the other eras.

Thus we would say of the Chemung, the Famennian, the Ilfracombe formations, each belongs to the Neodevonian period. The particular time value of each of these formations in a general time-scale we do not yet know with precision. Although the perfecting of knowledge will undoubtedly enable future geologists to define *epochs* and even *hemerœ*, in the general geological time-scale, our present knowledge of the succession of varieties and species is not sufficiently accurate to make their definition practicable for any extended region. While, therefore, we know the order of succession of faunas in local formations we may not be able to correlate our faunas with greater precision than to define periods for the standard time-scale. Common usage signifies that already this can be done so far as to recognize three-fold, or in some cases only two-fold subdivisions of the following eras, Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Triassic, Jurassic, Cretaceous and Tertiary. (Author's abstract.)

H. S. W.

2. *Le Tormaline del Granito Elbano* di GIOVANNI D'ACHIARDI, parte prima 8°, pp. 82, one plate, Pisa, 1893 (T. Nistri).—Prof. D'Achiardi states in his preface that the purpose of making a mineralogical study of the tourmalines of Elba was suggested by the immense richness of the material in the museum at Pisa and in the present part he gives the bibliography relating to the mineral and "treats of the morphology of the Elban tourmalines describing the crystal form in relation to their multiple varieties."

L. V. P.

3. *Auleitung zur Krystallberechnung* von Dr. BENNO HECHT. 8°, pp. 76. Leipzig, 1893 (Johann Barth).—This small volume gives in highly condensed shape the mathematical relations and formulæ necessary for the calculation of crystal forms and elements. The method employed is empirical and given from a purely mathematical standpoint. It will be of interest to those engaged in crystallographic studies. L. V. P.

4. *Cours de Mineralogie professé a la Faculté des Sciences de Parie* par CHARLES FRIEDEL, Mineralogie générale. 416 pp. 8°, Paris, 1893 (G. Massen).—The object of this text book, so we are informed by the author in the preface, is to supply a more general work and one which does not demand so much training

in mathematics as do the treatises of Mallard and de Lapparent, and to show as "simply as possible the methods that the science owes to crystallography, to physics and to chemistry in order to determine and classify minerals." L. V. P.

5. *Recherches Mineralogiques, Edition Posthume* par Prof. M. TOLSTOPIATOW. Moscow, 1893 (Leipsig in commission bei G. Weigand). 8°, pp. 136. 3 col. plates.—This memoir comprises the results, naturally in somewhat incomplete form, of the studies of the author, who was professor of mineralogy at the University of Moscow, in crystallogenesis and the optical and physical properties of crystals and the discussion of certain theories held by him relating to such phenomena. An obituary of the author is also added. L. V. P.

6. *A large unio-like shell from the Coal measures.*—Prof. Whiteaves describes in the Transactions of the Royal Society of Canada (Sect. iv, 1893, pp. 21–24, Pt. I), a large unio-like shell which he names *Asthenodonta Westoni*, discovered in the South Joggins coal field by Mr. T. C. Watson. The dimensions of the largest specimens are 200$^{mm}$ by 90$^{mm}$.

7. *Cretaceous in Northern Minnesota.*—H. V. Winchell reports the discovery of Cretaceous deposits of probable Colorado group age, in the Mesabi range, Section 20, twn. 58 N., Range 19 W. (American Geologist, vol. xii, p. 220.) W.

8. *On the evidences of a Submergence of Western Europe* and of the Mediterranean Coast, at the close of the Glacial or so-called Post-glacial Period, and immediately preceding the Neolithic, or Recent Period; by JOSEPH PRESTWICH, (Phil. trans. Roy. Soc. London, vol. clxxxiv (1893), A. pp. 903–984.)—The paper is illustrated by a map giving the position of the Rubble-drift and Raised Beaches for Europe and Northern Africa. The author believes that the phenomena discussed indicate a temporary submergence beneath deep waters (at least 200 or 300 feet about the shores of the Mediterranean), followed by re-elevation at the close of the Glacial period and commencement of the Neolithic age. W.

9. *The Canadian Ice Age*, being notes or the Pleistocene Geology of Canada, with special reference to the life of the Period and its climatal conditions, and lists of the specimens in the Museum (Peter Redpath Museum, McGill Unversity, Montreal); by Sir J. WILLIAM DAWSON. Scientific Publishing Co., New York, pp. 301.—The list of Pleistocene Fossils (chapter VI) has been carefully revised up to date and includes 240 species. The whole of the marine species with two or three exceptions, the author states, are living northern or Arctic forms belonging to moderate depths or varying from the littoral zone to 100 fathoms. Nearly all the marine species of the Leda clay and Saxicava sand are still living on the coasts opposite the points where the fossils occur. The shells of the lower bowlder clay and of the more inland and elevated beds, regarded as older than the lower terraces near the coast, are more Arctic in character.

The author further states that no remains of man or his works have yet been found in the Pleistocene of Canada; none of the implements discovered in alluvial deposits go further back than the modern period properly so called. W.

10. *Bulletin of the Dept. of Geology, University of California.* A. C. LAWSON, Editor, Berkeley, Cal.—Prof. Lawson states that it is the intention to issue these bulletins, each embodying a special piece of research, at irregular intervals, the bulletins to compose volumes of from 400–500 pages. The following numbers of Vol. I have thus far appeared. *No. 1, Geology of Carmelo Bay,* by A. C. Lawson, assisted by J. de la C. Posada. The structure, stratigraphy and geological history of the district are carefully, worked out. The petrology of the igneous rocks is considered in detail, accompanied by analyses. *No. 2, The Soda Rhyolite north of Berkeley,* by Chas. Palache. This is a detailed study of a very acid effusive rock in which soda is shown to be present in relatively large amount. *No. 3, The Eruptive Rocks of Point Bonita,* by L. F. Ransome. Another excellent petrological paper in which the mode of occurrence, petrography and chemical relations of a series of basic igneous rocks is carefully worked out. *No. 4, The Post-Pliocene Diastrophism of the Coast of Southern California,* by A. C. Lawson. This memoir contains the observations and reasoning by which two facts of general interest are established: "the uplift or emergence from the sea of the entire coast of California from San Francisco to San Diego in post-Pliocene time to an extent of from 800 to 1,500 feet," and "the local deformation or differential movement of the crust to a remarkable degree, particularly in the vicinity of San Catalina Island and near the city of San Francisco." These memoirs are well printed and accompanied by excellent maps, illustrations, diagrams, etc.

L. V. P.

11. *The Geological Survey of Missouri.*—The new Board of Managers of the Bureau of Geology and Mines met last week and passed a series of resolutions which contemplate a discontinuance of the geological survey of Missouri after June 1st next. The last State Legislature failed to appropriate sufficient money to maintain even a reduced force and to complete, let alone publish, the reports on hand. After careful consideration the best solution of the difficulty appeared to be the devotion of a greater part of the funds on hand and appropriated to the publication of three reports, on paleontology, lead and zinc, and clays respectively, in the order named, to abandon other work on reports on hand, whether nearly completed or not, and to suspend the work of the bureau with June 1st, the services of the State Geologist and his staff to be then dispensed with.—*The Age of Steel,* Jan. 6, 1893.

12. *Geikie's Fragments of Earth Lore.**—This work is a collection of articles some of which have been delivered as addresses

* Fragments of Earth Lore: sketches and addresses, geological and geographical. By JAMES GEIKIE. Edinburgh, 1893.

before various learned societies, while others have been published in various periodicals. Of the fourteen chapters of the book, one discusses the general relations between geography and geology, with special reference to methods of teaching geography; three are descriptions of the geology of Scotland, or of particular facts of that country; four treat of the evolution of the main geographical features of the earth; and six are devoted to the discussion of various phases of the Glacial Period. The dates of delivery or publication of the articles range from 1876 to 1892. As each article was intended to be complete in itself, and they have been republished in the present volume with little revision, there is inevitably considerable repetition. But each article is a valuable contribution to the knowledge of the subject of which it treats. Without attempting to notice the several articles in detail, we propose to call attention to some of the most important conclusions, in relation to the two important subjects to whose discussion the majority of the papers are devoted.

I. Geographical Evolution.

The author maintains the doctrine of the permanence of continents and oceans, giving credit to Professor Dana for the first clear enunciation of that doctrine.* In support of that doctrine, he refers to the contrast between the formations in progress at the bottom of the ocean, as made known by the naturalists of the Challenger and other expeditions for the investigation of the ocean, and the materials of which the surface of our continents and islands consist.† Certain it is that the rocks of existing land surfaces are in general very different from the volcanic clays and organic oozes of the ocean floor.

Assuming the substantial permanence of continent and ocean, in the sense of areas respectively of relative elevation and relative subsidence, the author holds that the progressive relative subsidence of the ocean basins has led to a progressive emergence of the continental areas, and accordingly a progressive increase in the area of dry land. That, in spite of all oscillations, this has been the general course of geological history, there seems little reason to doubt. A very interesting series of maps is given,‡ showing the areas of land and sea in Paleozoic, Mesozoic, and Cenozoic times, respectively. It is needless to say that the indications given by these maps are intended only as approximations; but they present a picture of geographical evolution whose main outlines are doubtless true. These maps are accompanied by a fourth, in which the areas respectively of dominant depression and elevation are distinguished, the contour line of 1000 fathoms being taken as the boundary. This boundary, is, however, recognized as an arbitrary one,§ since it is obvious "that the true boundary of the continental plateau cannot lie parallel to the surface of the ocean."

* Page 326. † Page 327. ‡ Plate V.
§ Page 378.

In Chapters XI and XIV, the law of continental evolution by gradual emergence is illustrated in the geological history of Europe.

In Chapter III the author gives a classification of mountains, dividing them into mountains of accumulation, mountains of elevation, and mountains of circumdenudation.*

The chapter on Mountains presents some very interesting views in regard to the decay of mountains under erosive agencies. The weakness of anticlinals, and their tendency to degradation is shown in a very striking way.† The tendency to the formation of synclinal ridges and anticlinal valleys is, nevertheless, stated, in our judgment, rather too broadly. Davis has shown that the preservation or reversal of the primitive topography of anticlinal ridges and synclinal valleys depends on the particular relation between hard beds and the base level of the streams.‡ An interesting suggestion of our author is that of the frequency of disastrous rock-falls in the Alps and other young mountain ranges, as compared with their rarity in old mountain regions.§ In the latter case there has been time for the removal of all especially weak and unstable structures.

The Evolution of Climate is discussed in Chapter XII. Our author follows Heilprin in doubting the sufficiency of Neumayr's evidence of the differentiation of climatic zones in the Jurassic.‖ Cosmopolitan species are, however, less numerous in the Cretaceous than in earlier formations; and in the Tertiary the distinction of zones is unquestionable.¶ The temperate climate of high northern latitudes even as late as the Tertiary our author attributes to the submergence of a great tract in Asia, of which the Aralo-Caspian depression is a remnant, permitting warm currents from the Indian Ocean to find their way into the Arctic.**

Professor Geikie maintains Croll's theory of the cause of the Glacial Period. Although the small amount of dry land in the early periods, and the free movements of warm waters into Arctic regions, rendered any general glaciation impossible, he yet believes that, in epochs of high eccentricity, the temperature was so far reduced as to develop ice action in some localities. Traces of such action, he believes, are found as early as the Devonian, in the Lammermuir and Cheviot Hills.††

### II. The Glacial Period.

It is needless to say that Prof. Geikie adheres to the doctrine that the characteristic phenomena of the Drift are due chiefly to land ice. There is so general agreement among geologists on that conclusion, that argument thereon is well nigh superfluous. We will, however, call attention to the exceedingly interesting discussion in Chapter VII, on The Intercrossing of Erratics in Glacial Deposits. The objection sometimes still offered to the

* Page 44.
† Page 52.
‡ Science, xiii, 320.
§ Page 51.
‖ Page 360.
¶ Page 364.
** Page 365.
†† Pages 87, 371.

glacier theory, based on the transportation of bowlders in different or opposite directions over the same area, as if they had been borne by icebergs driven about by changing winds, is triumphantly answered. In the case of a number of localities in France, Germany, and Britain, it is shown that the comparatively local glaciers of an incipient or waning glacial epoch would necessarily move in a different—sometimes even in an opposite—direction from that of the portions of the huge confluent glaciers by which the same regions were covered in the culmination of a glacial epoch. The phenomena in question are thus shown to be an inevitable consequence of the glacier theory.

In this, as in his former works, Professor Geikie advocates the doctrine of a plurality of glacial epochs. The following is the series of Glacial Epochs, according to his latest views:*

"1. *Epoch of Earliest Baltic Glacier.*—Lowest bowlder-clay of southern Sweden; lowest bowlder-clay of Baltic provinces of Prussia; horizon of the Weybourn Crag.

2. *Epoch of Greatest Mer de Glace.*—Lower bowlder-clays of middle and southern Germany, central Russia, British Islands; second bowlder-clay of Baltic provinces of Prussia.

3. *Epoch of Lesser Mer de Glace.*—Upper bowlder-clay of western and middle Germany, Poland, and west central Russia; upper bowlder-clay of Britain; third bowlder-clay of Baltic provinces of Prussia.

4. *Epoch of Last Great Baltic Glacier.*—Upper bowlder-clay and terminal moraines of Baltic coast-lands; district and valley moraines of Highlands and Uplands of British Islands.

5. *Epoch of Small Local Glaciers.*—Valley moraines in mountainous regions of Britain, etc."

A fuller presentation of the evidence of the views set forth in the above table is promised in the forthcoming new edition of "The Great Ice Age."

The problem of the Loess is the subject of valuable discussion.† The eolian theory is rejected, largely on the ground that the prevalence of an excessively dry climate is inconceivable, since "the loess is intimately associated with accumulations, the glacial and fluvio-glacial origin of which cannot be doubted."‡ The loess is considered, in the main, "an inundation-mud deposited in temporary lakes and over flooded areas during the summer meltings of the snow- and ice-fields." Darwin's suggestion is approved, that many valleys were choked with snow, whereby the flooded rivers were often compelled to flow in temporary channels at levels far above the bottoms of the valleys§—a suggestion which finds confirmation in some remarkable phenomena observed in Alaska. The loess of north Germany is held to have been formed in a lake enclosed between the front of the ice-sheet and the foot-hills of the mountains of central Germany.‖

* Page 325. † Pages 176, 236. ‡ Page 177.
§ Page 180. ‖ Page 182.

Professor Geikie appeals to the occurrence of boreal and arctic shells in Quaternary marine deposits as proving that glacial conditions have been for some reason associated with submergence rather than with emergence of the land. "Each glacial epoch," he says, "was preceded and accompanied by partial submergence of the land."* We query whether the correlation of the deposits has been worked out with sufficient accuracy to exclude the view of LeConte, that a glacial climate may have been preceded and occasioned by elevation, but may have continued after considerable subsidence had taken place, the various effects lagging behind their causes.† It may be remarked parenthetically that Professor Geikie no longer holds to a deep Quaternary submergence of Britain, regarding the marine shells of Moel Tryfaen as "erratics."‡

The co-existence of northern and southern forms of vegetation in interglacial deposits is appealed to as showing that the climate in such epochs was exactly what the eccentricity theory requires —a climate of mild winters and cool summers.§

Professor Geikie refers to the estimates of Gilbert and Winchell on the recession of Niagara and St. Anthony's Falls, but rejects them as unreliable.‖

The relation of the succession of geological events in the Quaternary to the history man, is briefly treated. It is maintained that paleolithic man and the southern pachyderms with which he had been associated retired from England before the epoch of the Second Mer de Glace [the third of the five glacial epochs in the table which we have quoted], and never returned to Britain or northwestern Europe.¶

In conclusion, we would express our regret that a book of over four hundred octavo pages, containing so much that is interesting and valuable of fact and theory, should not be provided with an index.

13. *Economic Geology of the United States;* by RALPH S. TARR (Cornell University), pp. 509 (Macmillan & Co.), 1894.— This is the latest of the attempts to popularize the facts of geology by presenting them from the point of view of local distribution and commercial value, and from this point of view is well adapted for the American students. Economic geology was introduced as a special feature at Cornell University first with the use of David Page's Economic Geology, or Geology in its relations to the Arts and Manufactures (1874), a year or two later an elaborate synopsis of lectures for the course was prepared by T. B. Comstock. Later (1886) Samuel G. Williams, now Professor of Pedagogy at Cornell, prepared Applied Geology (Appleton's) on the same lines. In 1893 appeared Ore deposits of the United States, by James F. Kemp (now Professor of Geology at Columbia School of Mines), (The Scientific publishing company) 1894, a valuable work for others than elementary students. The

* Page 321. † Bull. Geol. Soc. Am., iii, 329. ‡ Page 173.
§ Page 385. ‖ Page 286. ¶ Page 243.

present work is much on the same plan as Page's book with the statistics and distribution of American products made more complete and prominent; and the author has added several excellent chapters on structural geology and physical geography which removes the book from being an aggregate of statistics regarding valuable geological products. W.

## III. Astronomy and Seismology.

1. *The force that acts on the meteoroids after they have left the comets.*—(Communication by H. A. Newton to the American Philosophical Society at its recent sesquicentennial.)

There are in the comets so many questions that we cannot answer, so many curious and wonderful phenomena that are unexplained, that I am sure you will accept any explanation of any of them that seems plausible, as a matter of interest. From a comet there is continually driven off matter forming the tail, a light substance, and astronomers are agreed that the force that acts on the matter which forms the tail is a repulsive force from the sun acting inversely as the square of the distance, the force of the repulsion being greater than that of attraction.

Not only is this true, but different parts of that tail are acted upon by repulsive forces of different powers; otherwise the tail would form across the sky a single line instead of a broad, expanded mass of light such as we see. From the comet, however, there are driven off also, or there are separated other things entirely distinct from the tail, small bodies, which are not thus driven away, which are not visible, but follow along closely in the path of the comet, and whenever the occasion comes, that is when we go through a group of them, those give us our shooting stars.

The Biela comet, in the period about 1840, passed near to Jupiter. At that time it was turned pretty sharply out of its orbit, the inclination of the orbit being turned several degrees, and the node being carried forward also several degrees, represented by several days in the time at which we crossed the path of the comet.

After 1840 the bodies which formed the meteors that were met in 1872 and in 1885 were separated from one or other parts of the Biela comet. I say after 1840, because if they had been separated earlier they would have given us a different radiant in the skies, the one given by the Biela meteors of 1838. The radiant was changed, the node was changed, all to correspond to the new orbit, and these bodies could not have been turned in that way had they been before scattered, because the force that acted on them, the attraction of Jupiter, would have scattered the group instead of giving us that single compact group through which we passed in 1872 and 1885 in the course of four or five hours, and the bulk of them even in two hours.

In 1872, the comet was something like 200,000,000 miles away from the bodies that we met as we passed through them on the 27th of November, giving us a brilliant shower. Thirteen years later we passed through the group again, and then we were something like 300,000,000 miles ahead of the group. So that some of the particles, leaving the comet between 1840 and 1870, had fallen behind and others between 1840 and 1885 had gained.

What should separate those particles? What are the forces which carried off those particles so many miles—200,000,000 miles on the one hand and 300,000,000 miles on the other, in round numbers? The force that acts on them must be a force acting in one plane, that is, the plane of the orbit of the comet. Any force acting in other planes would have scattered the group and we would not have met them as a single definite group at the times named; but if it acts in the plane, only scattering them on the plane, they would be together as we saw them.

In that plane, it must be either an impulsive force acting once or it must be a constant force acting continually. The only bodies in that plane are the comets and the sun, and if the force is a continuous force it must be from the comet or from the sun. It is almost inconceivable to suppose that the comet could have sent them off, either impulsively or continuously, in such a way as to give us the distance of 200,000,000 and 300,000,000 miles in the course of thirty years; it would require far more than any velocity that we can give in our terrestrial experiments, and we have no reason to suppose that there is any such power of impulsion. Moreover, if the impulsion came from the comet, they would go in all directions and their character, as being in a plane, would have been entirely lost.

We are then thrown back on this one hypothesis, that the sun is the source of that force. In other words, we are led to extend the idea that I gave you in the beginning, and which is accepted by astronomers, that the material which goes off from the comet, after it leaves it, is subject to a force like that of attraction but differing in its intensity. In the case of the tail, it is a repulsive force. To satisfy these conditions of separation, part in one direction and part in the other, from the comet, we must have an attraction in the one case exceeding the attraction of gravitation and, in the other, an attraction less than the attraction of gravitation. In other words, these little bodies of hard matter that go off from the comet and follow very nearly in its train are acted on not in proportion to this mass like the force that acts on the planets in their orbits.

I see no escape, myself, from this conclusion. What it means, I must leave to you to decide. Our experiments make it very improbable that the attraction of matter differs in any way from proportion to the mass. It looks to me as though the more natural explanation is that, in some way, the materials which go off from the comet carry with them a load of electricity, or something of that kind, by which they have a permanent repul-

sion or permanent atttraction sufficient to change the orbit altogether, not in kind, but in a steady change, throwing them into a new orbit with a new period, and thus scattering them.

What that added force must be, we cannot very well tell, because it differs according to the place in the orbit where the disintegration takes place. If that disintegration takes place near the sun, it is one thing; if it takes place near Jupiter, it is another. It looks more to me as though there was a disintegration all along the line of the comet's orbit, giving us small particles with all sorts of loads of electricity and all sorts of differences of central attraction and differences of orbits, and thus they get widely scattered so as to give us the showers a long distance from the comet itself. The maximum amount of this change would have to be something like the tenth part, possibly, or something less than that. I should think that all the phenomena of the meteoroids could be explained by a change amounting to one-tenth of the attraction; that is, if the small particle carries a load of electricity such as to diminish the attraction to say nine-tenths of the original attractive force of the sun, or increase it to eleven-tenths, it will explain the phenomena.

If that is the explanation, we come to this further conclusion of interest, that the space through which these comets move is not such that the electricity which the particle carries can be lost. Another practical point would be that, in the discussion of the separation of these comet masses that through the telescope we see going on as the comets pass the sun, there might fairly be introduced an unknown correction of the force of central attraction.

2. *Photographs of August and December Meteors.*—At the Yale Observatory Dr. Elkin made trial in August last to determine whether, with a reasonable amount of labor, tracks of meteor flights could be secured upon photographic plates. On the evening of Aug. 9th, he exposed three plates. The camera had a six inch lens of thirty-two inches focus. This instrument had been purchased and presented to the Observatory by Mr. Cyprian S. Brainerd of Brooklyn who was interested in the experiments. It was attached to the mounting of the eight-inch equatorial and directed as nearly as convenient to the radiant in Perseus. The total time of exposure was four hours, and during the period careful watch was kept to note the time, etc. of any meteors crossing that part of the heavens which would appear on the plate. Three meteor tracks were secured, one of which was very bright and left on the plate a line nearly six degrees long. This is a true Perseid, as was one of the other two tracks.

On the same evening Mr. John E. Lewis of Ansonia exposed plates in a stationary camera, and the brightest of the three tracks was secured on one of his plates. A provisional computation shows that this meteor first begun to print its path on the Observatory plate at a height from the sea-level of 68·0 miles. It ceased to print when it was 51·65 miles high. The length of

track between these points was 29·3 miles. The velocity with which a Perseid enters the air is 37·2 miles per second; hence the duration of the flight was probably less than one second.

On the following evening plates were exposed without success. Everything was in readiness on the 15th and 16th of November, in case the Leonids should appear in sufficient numbers to justify the exposure of plates. The moonlight and clouds interfered on the 23d to 27th of November, when the Bielids might possibly appear in moderate numbers.

On the evening of December 10th, the work was again resumed, and several plates were exposed, two cameras being used. They were directed near to the Geminid radiant, and three tracks of true Geminids were secured. Mr. Lewis at Ansonia joined in the work, but upon his plates only one possible trace was printed. This is too doubtful to be safely used.

The three Observatory tracks meet very nearly in a point. In fact a provisional computation based upon the Bonn charts, and allowing for differences of zenith attraction of the meteors makes the circle inscribed in the small triangle formed by the tracks produced backward less than one minute in diameter. The Bonn Durchmusterung star-places do not justify this degree of accuracy.

The experiment shows that with a reasonable amount of labor we can get photographs of meteor tracks. The accuracy of results obtained from the photographs is unspeakably greater than those gotten by any other known method. H. A. N.

3. *On the Annual and Semi-annual Seismic Periods;* by CHARLES DAVISON, (from the Proceedings of the Royal Society, vol. liv, pp. 82–85.)—(Abstract). *Method of Investigation.*—The method adopted is similar to that employed by Dr. C. G. Knott in his paper on "Earthquake Frequency."

A definition of the unit earthquake having been adopted, the earthquakes of different districts are classified in half-monthly groups, the first half of February containing fourteen days, and of all the other months fifteen days; and the numbers so obtained are reduced to intervals of equal length (fifteen days). The numbers for the two halves of each month are added together. The mean of the numbers for the six months from November to April gives the six-monthly mean corresponding to the end of January. Six-monthly means are calculated in this way for the end of each month; each mean is divided by the average of all twelve, and the difference between each quotient and unity is multiplied by the augmenting factor 1·589, in order to obtain the correct value of the ratio $a_1 : a_0$. The curve obtained by plotting these reduced means thus gives special prominence to the annual period, by eliminating the semi-annual period and all those which are fractions of six months, and by diminishing the amplitudes of all other periods with respect to that of the annual period.

In investigating the semi-annual period, the numbers corresponding to the first halves of January and July are added to-

gether, and so on; the rest of the method being the same as for the annual period. The result gives special prominence to the semi-annual period by eliminating the annual period, and by eliminating or diminishing the amplitudes of all periods less than six months.

*Seismic Periodicity in relation to Intensity.*—This discussion is founded on: (1) lists compiled from Mallet's great catalogue, first, of shocks which were so slight as to be just perceptible, and, secondly, of those which were strong enough to damage buildings; (2) Professor Milne's classification of the Japanese earthquakes of 1885 to 1889 according to the areas disturbed by them; and (3) different catalogues relating to the same district, it being obvious that two such catalogues for the same time can only differ by the omission or inclusion of slight shocks.

The following results are obtained: (1) In both periods, the amplitude is greater for slight than for strong shocks; (2) there appear to be two classes of slight shocks with an annual period, the stronger having their maximum in winter, the weaker in summer; and (3) in the case of the semi-annual period, both strong and slight shocks, as a rule, have nearly the same maximum epochs.

*Seismic Periodicity in relation to Geographical Position.*—The number of records examined is 62, 45 belonging to the northern hemisphere, 14 to the southern, and 3 to equatorial countries.

*Annual Period.*—In every district, and in all but five records (which are obviously incomplete), there is a fairly well-marked annual period. As a rule, different records for the same district agree in giving the same, or nearly the same, maximum epoch. Excluding, however, those which disagree in this respect, we have left 34 records for the northern hemisphere, 9 for the southern, and 2 for equatorial countries. In the northern hemisphere, 4 records give the maximum in November, 16 in December, and 6 in January; in the southern hemisphere, 2 in April, 2 in May, 3 in July, and 2 in August; the end of the month being supposed in each case. As a rule, then, the maximum epoch occurs in winter in both hemispheres. The amplitude of the annual period ranges from 0·05 (New Zealand) to 0·67 (Sicily and Algeria) the average of 57 records being 0·33.

*Semi-annual Period.*—Of the 62 records examined, only 3 fail to show a semi-annual period, the cause of the failure in these cases being no doubt the imperfection of the seismic record. In New Zealand and Southeast Australia, the maximum epoch generally falls either in February or March and August or September; in North America, as a rule, in March or April and September or October. But for other regions it does not seem possible as yet to deduce any law. The amplitude of the semi-annual period ranges from 0·06 (southern hemisphere) to 0·79 (Mexico), the average value being 0·24.

In fifteen cases, the amplitude of the semi-annual period exceeds that of the annual period. Eleven of these records

include the following insular districts, which are among the most well-marked seismic regions in the world, namely, the Grecian Archipelago, Japan, the Malay Archipelago, New Zealand, and the West Indies. The average amplitude of the annual period in these eleven cases is 0·16, and that of the semi-annual period 0·24; *i. e.*, the average amplitude of the annual period is just half that for all the districts examined, while in the case of the semi-annual period the average amplitudes are the same.

*Origin of the Annual Period.*—In this, the concluding, section of the paper, an attempt is made to show that the annual change in barometric pressure may be the cause of the annual change in seismic frequency. It would be difficult to prove that such a connection exists, but reasons are given which seem to render it in some degree probable.

The most probable cause of the origin of the majority of non-volcanic earthquakes is the impulsive friction, due to slipping, of the two rock-surfaces of a fault. Now, whatever be the causes of seismic periodicity, it seems probable that they are merely auxiliary, and determine the epoch when an earthquake shall take place, rather than there shall be an earthquake at all. Professor G. H. Darwin has shown that the vertical displacement of the earth's surface by parallel waves of barometric elevation and depression is not inconsiderable, and that it diminishes at first very slowly as the depth increases. Since the fault-slip which produces even a moderately strong shock must be very small, and since the work to be done in such a case is, not the compression of solid rock, but the slight depression of a fractured mass whose support is nearly, but not quite, withdrawn, the annual range of barometric pressure does not seem incompetent to produce the effects observed.

Comparisons between the dates of the maximum epochs of the seismic and barometric annual periods are made in 31 of the districts treated in this paper. The seismic maximum approximately coincides with the barometric maximum in 10 districts, and follows it by about one month in 9, and by about two months in 4, districts; the other cases generally admitting of some explanation.

In several insular seismic districts, and especially in Japan and New Zealand, the amplitude of the annual period is very small; and, if many of the earthquakes of these districts originate beneath the sea, this should be the case; for, in the course of a year, as the barometric pressure changes, the sea will have time to take up its equilibrium position, and thus the total pressure on the sea-bottom will be unaltered.

## IV. Miscellaneous Scientific Intelligence.

1. *On the laws of organic growth. Bioplastology and the related branches of Biologic research*; by Alpheus Hyatt. (Proc. Boston Soc. Nat. Hist., vol. xxvi, pp. 59–125.)—Prof. Hyatt

has contributed greatly to the elucidation of the laws of embryological development and its relation to paleontological succession in his numerous papers on Cephalopods. Stimulated by some criticism of his nomenclature, recently made by Messrs. Buckman and Bather,* he has set forth at considerable length and detail his views regarding the four different lines of research which are usually described by the popular terms growth, heredity, acquired characteristics and the correlations of development of the individual (ontogeny), with the evolution of the group to which it belongs (phylogeny). He proposes to use the technical names *auxology* or *bathmology* for the first, *genesiology*, for heredity; *ctetology* for the origin of acquired characters and *bioplastology* for the correlation of ontogeny and phylogeny, and describes the field of research and the special nomenclature required for each. As an analysis of the precise methods of research of the advanced investigators in biology this is a useful and timely contribution.

W.

2. *A Bibliography of Vertebrate Embryology*, by CHAS. S. MINOT (Memoirs Boston Society Nat. Hist., vol. iv, No. XI, pp. 487–614).—This is an elaborate, thoroughly classified list of 3555 titles of works treating directly or indirectly upon vertebrate embryology, classified primarily under 64 groups of subjects, then by authors alphabetically arranged.

3. *A theory of Development and Heredity*, by HENRY B. ORR, Ph.D., 225 pp. 8vo, (Macmillan & Co.)—This is a theory of evolution from the psycho-physiological point of view. The substance of Prof. Orr's theory is given in the following sentences: "It would be difficult in the face of the facts to imagine that organic development differs in nature from psychic activity, or rather to speak more accurately, from the material accompaniment of psychic activity" (p. 239), and "the intelligent human action and the simplest process of growth are thus alike the necessary result of the stimuli which are momentarily acting, and those which have acted upon the organism through its racial and individual existence" (p. 242). W.

4. *Bulletin from the Laboratories of Natural History of the State University of Iowa.* Vol. II, No. 4, pp. 295–415, Plates I–XII, Nov., 1893. Iowa City, Iowa.—This number contains ten separate papers, the majority of which are micro-anatomical studies of animals and plants. Mr. Shimek in the fifth paper gives an account of a Botanical Expedition to Nicaragua in which the country traversed and its climatic conditions are described. The number and kinds of plants gathered is given but without generic or specific definition. Prof. McBride described (p. 391) a new Cycad, *Bennettites Dacotensis* from supposed Mesozoic rocks, near Minnekahta, S. Dak., the description having originally appeared in Am. Geologist, Oct., 1893. W.

5. *Horns and Hoofs, or Chapters on Hoofed Animals;* by R. LYDEKKER, pp. 411 (Horace Cox, London, 1893).—The work is a

* Zool. Anz, xv, p. 420 and 429, Nov. 1892.

popular treatment of the Natural History of hoofed big game of all parts of the world, in which is found, of scientific interest, the discussion of their present and past distribution. Numerous illustrations of the horns of the different species are inserted in the text. W.

6. *Our native Birds of song and beauty;* by HENRY NEHRLING. Vol. I, pp. i–l; and 371 (George Brumder, Milwaukee).—This is a beautifully made book containing eighteen, full page, colored plates illustrating the song birds and flycatchers of North America. Prepared for the general public, it contains information of scientific interest regarding the geographical distributions and habits of the birds under discussion. W.

7. *Les Émules de Darwin*, by A. DE QUATREFAGES. Two vols. 1894 (Félix Alcan, Paris).—A preface by Edmond Perrier, introduces the first volume, followed by a notice of the life and works of M. Quartrefages by E. T. Haamy. The author has attempted to review the conceptions of the chief rivals of Darwin, those who have either advanced new theories or have sought to perfect the Darwinian theory, and the following names have been considered: Alfred R. Wallace, M. Naudin, M. J. Romanes, Carl Vogt, Ernest Haeckel, T. H. Huxley, Richard Owen, St. G. Mivart, A. Gubler and A. Koelliker, M. Trury, D'Omalreius d'Halloy, and Erasmus Darwin.

Upon closing the book the author says (translated): "From this detailed examination, which we have endeavored to make as impartial as possible, one unpleasant impression is left: that of our inability to solve actually the great problem which so many eminent men have attacked in vain. The beginning of life upon the earth remains for all an impenetrable mystery. We are unable to assign any plausible cause for the transformations which the composition of faunas and floras have suffered. The modifications of which actually living forms are susceptible are capable of forming only *varieties* and *races*, no one has been able to produce a new *species*. The species remains an indelible entity, like that of the simple elements of chemistry.

Perhaps the darkness which envelopes the origin of the organic world will some day clear up. Science has shown too great power to make it prudent to assign limits to it. We will not repeat, in conclusion the *ignorabimus* of Dubois-Raymond, we will say only *ignoramus*. W.

8. *Bibliotheca Zoologica* II. Verzeichniss der scriften über Zoologie welche in den periodischen werken enthalten und von Jahre 1861–1880 selbständig erschienen sind. Bearbeitet von Dr. O. Taschenburg. Elfte Lieferung, pp. 3249–3568. (Wilhelm Engelmann, Leipsig, 1893).—The number of this valuable work just issued contains the continuation of the Bibliography of Fishes and commences that of Amphibia and Reptiles.

9. *The Mechanics of Hoisting Machinery;* by WIESBACH and HERRMANN. Translated by Karl Dahlstrom, M.E. pp. 329, with 177 diagrams (Macmillan and Co.).—A part of Wiesbach's great

series on Engineering Mechanics, other parts of which have been translated by Coxe, DuBois and Klein. B.

10. *An Elementary Treatise on Fourier's Series* and *Spherical, Cylindrical and Ellipsoidal Harmonies;* by W. E. BYERLY. pp. 287 (Ginn & Co.). Based upon Rumaun's "Partialle Differentialgliechungen" and designed to furnish with Pierce's treatise on "The Newtonian Potential Function" a course of study for students at Harvard University preparatory to modern Mathematical Physics. B.

*Geological Survey of Texas.* Annual Report for 1892, E. T. Dumble, State Geologist. The following parts have appeared since the notice in this Journal, vol. xlvi, p. 307 was written:

*Notes on the Geology of Northwestern Texas*, by W. F. Cummins, pp. 177–238.

*Report on the Cretaceous Area north of the Colorado river*, by J. A. Taff, S. Leverett, Assistant, pp. 239–354, with maps and sectional diagrams.

*Report on the Colorado Coal field of Texas*, by N. F. Drake and R. A. Thompson, pp. 355–481, with maps and diagrams.

*Arkansas Geological Survey*, Annual Report for 1890. John C. Branner, State Geologist, vol. iv.

Marbles and other Limestones, by T. C. Hopkins. 443 pages and 6 maps separately bound.

*Annals of British Geology*, 1892. A digest of the books and papers published during the year—with occasional notes, by J. F. Blake. pp. 310, 100 illustrations. (Dulan & Co, London, 1893.)

*Memoirs of the American Museum of Natural History.* vol. i, Part I. Republication of descriptions of Lower Carboniferous Crinoidea from the Hall Collection now in the American Museum of Natural History, with illustrations of the original type specimens not heretofore figured. By R. P. Whitfield, 4to, pp. 1–37, Plates I–III. 1893.

*Economical Geology of the United States*, by Ralph S. Tarr. pp. 509. 1894. (Macmillan & Co.)

*Helical Gears;* A practical treatise by a foreman pattern maker. pp. 127, 1894. (Macmillan & Co.)

*Die Vorwelt und ihre Entwickelungsgeschichte*, by Ernst Koken. pp. 654, 1893. (T. O. Weigel Nachfolger (Chr. Herm. Tauchnitz).)

## OBITUARY.

RUDOLF WOLF, the distinguished Astronomer and for sometime Director of the Zurich Observatory, died in Zurich, Nov. 6, 1893.

PAUL FISCHER, author of Manuel de Conchyliologie et de Paléontologie Conchyliologique and of numerous papers on conchological subjects, died in Paris, Dec. 29, 1893.

D. A. BRAUNNS, Extraordinary Professor of Geology in Halle University died in 1893.

ARTHUR MILNES MARSHALL, the brilliant Professor of Zoology of Owens College, Manchester, died from the effects of an accident on Scawfell, Dec. 31, 1893, in the forty-second year of his age.

PIERRE T. VAN BENEDEN, Professor of Zoology, Paleontology and Anatomy, Lourain, has recently died at the age of ninety-three.

JEAN VILANOVA Y PIERA, the distinguished geologist of Madrid is dead.

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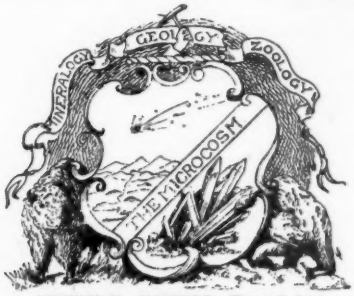


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